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South Africa's Pro-Girl Gap in PIRLS and TIMSS: How Much Can Be Explained?

Heleen Hofmeyr[1,2]

Abstract:

This paper analyses South Africa's pro-girl gap in Grade 4 reading and Grade 5 mathematics achievement. I make use of Oaxaca-Blinder decomposition analysis to decompose the observed gender gaps into their explained and unexplained components, separately by school socio-economic quintile. Contributing to a growing body of evidence internationally that pro-girl gaps in education may be due to girls having better-developed non-cognitive skills than boys, I find that South African girls display more of the traits and behaviours that are associated with school achievement than boys. Interestingly, the results of the decomposition analysis suggest that these factors explain a larger proportion of the pro-girl gap in Grade 4 reading than Grade 5 mathematics. The results further indicate that although part of South Africa's pro-girl gap in PIRLS and TIMSS is attributable to a female advantage in grade completion in the early grades, there is still much about South Africa's pro-girl advantage in education that remains unexplained.

1. Introduction

Increasing girls' participation in education has been a central feature of efforts to promote educational equality in developing countries. What has received less attention in both the literature and policy debates is that gender issues in education vary considerably across the developing world. One major area of divergence is that while some developing countries are still struggling to achieve gender parity in school enrolment (Grant and Behrman, 2010), others exhibit the same pro-girl advantage in education as is observed in most of the industrialised world (Badr, Morrissey and Appleton, 2012). South Africa is one such a developing country where girls systematically achieve better educational outcomes than boys. Girls achieve better results in virtually all the international educational assessments South Africa participates in (Van Broekhuizen and Spaull, 2017; Zuze *et al.*, 2017; Spaull and Makaluza, 2019), are less likely to repeat a grade and drop out of school (Van der Berg *et al.*, 2019), and achieve better results in *matric* – the school-leaving exam in South Africa (Spaull and Makaluza, 2019). This pro-girl achievement gap in basic education continues through higher education, where women are 34% more likely to enrol in undergraduate programmes than men on average, and 62% more likely to complete their undergraduate degrees than men (Van Broekhuizen and Spaull, 2017). While a pro-female

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advantage in education is not in itself unusual - most industrialised countries exhibit similar pro-female gender gaps in basic and higher education (Jacob, 2002) - South Africa's pro-girl achievement gap is noteworthy for at least two reasons: (i) The fact that such a distinct and persistent gap exists in an education system that is in many ways more similar to those in developing countries; and (ii) The magnitude of the gap, especially in the primary school grades - the pro-girl advantage in Grade 4 reading achievement is roughly *four times* as large as that observed in other countries[3].

Although these features of South Africa's pro-girl achievement gap are in themselves noteworthy, these country-level averages mask important differences in the magnitude and extent of the gender achievement gap across socio-economic and schooling contexts in South Africa. The handful of local studies that investigate differences in the magnitude of the gender achievement gap in South Africa present evidence to suggest that gender and SES intersect in meaningful ways to produce learning outcomes (Van Broekhuizen and Spaull, 2017; Zuze and Beku, 2019), a result which has largely been overlooked in local research, at least compared with the international literature, where the intersection between SES and gender in influencing educational outcomes has received considerable attention.

Another feature of the pro-girl achievement gap in South Africa that has received little attention is potential sources of this gap. While the international literature has been concerned with identifying the sources of the pro-girl advantage in educational outcomes for more than two decades, local studies have generally focussed more on documenting gender gaps in education rather than attempting to provide explanations for them (see Van Broekhuizen and Spaull (2017); Spaull and Makaluza (2019); Zuze and Beku (2019)). The aim of this paper is therefore to interrogate potential reasons for the pro-girl achievement gap in South Africa. Specifically, given mounting evidence from the international literature of the importance of gender differences in non-cognitive skills – such as attitudes toward school and learning - in explaining gender achievement gaps, the analysis in this paper is aimed at examining the extent to which potential differences between boys and girls in these skills can explain the pro-girl achievement gap in South Africa.

The main econometric strategy employed to this end is Oaxaca-Blinder decomposition analysis, whereby the pro-girl gap in achievement is split into two components - that which can be explained due to gender differences in observable characteristics, and that which remains unexplained. The decomposition analysis is performed separately on South African data from two international educational assessments, namely the Progress in International Reading Literacy Study (PIRLS), which tests reading in Grade 4, and the Trends in Mathematics and Science Study (TIMSS), which tests mathematics in Grade 5.[4] Importantly, given evidence of gender differences in grade repetition in

[3] This is according to South Africa's PIRLS (2016) results. South Africa's pro-girl advantage is roughly four times as large as the average pro-girl gap across all participating countries (Mullis *et al.*, 2017).

[4] While most countries participate in the TIMSS study in Grade 4, countries can choose to participate in Grade 5 if they suspect that the assessment will be too difficult for Grade 4 students.

Grades 1-3, I perform two separate sets of decomposition analyses - one on the full PIRLS and TIMSS samples, and one on restricted samples of these datasets where I attempt to control for gendered repetition patterns in prior grades. This is done in order to determine whether other observable differences between boys and girls – apart from being overage – contribute to the observed pro-girl achievement gaps. Given evidence from the international literature that the magnitude and potential sources of gender achievement gaps tend to differ by SES, each decomposition analysis is performed separately by school quintile within each dataset. This approach allows me to investigate potential SES differences in the magnitude and factors contributing to South Africa's pro-girl gap in both Grade 4 reading and Grade 5 mathematics achievement.

This paper makes four important contributions to the literature on South Africa's pro-girl advantage in educational outcomes. Firstly, I show that around half of the pro-girl achievement gaps in PIRLS and TIMSS can be explained by observable differences between boys and girls. While this explained proportion is comparable to studies conducted in other countries that use a similar methodology, this result still means that around half of the pro-girl achievement gap remains unexplained.

Secondly, the results from the decomposition analysis suggest part of the observed pro-girl achievement gap in both PIRLS and TIMSS is explained by boys being much more likely to be overage for their grade than girls. Since being overage is an indicator of having repeated a grade, this implies that any given Grade 4 or 5 class will consist of a larger proportion of boys than girls who have repeated an earlier grade. In this sense, boys in these grades are already "selected" to be weaker performers than their female peers. While one may expect grade repetition to be associated with learning gains, whereby repeaters "catch up" their initial backlog in learning, existing evidence suggests that grade repetition does not achieve this aim in South Africa, since repeating a grade is associated with weaker subsequent performance (Anderson, Case and Lam, 2001; Van der Berg *et al.*, 2019). Part of the observed pro-girl achievement gaps in PIRLS and TIMSS can therefore be attributed to a female advantage that is already evident at the start of formal schooling and accumulates over the early grades. This result constitutes an important contribution to the literature on gender gaps in achievement in countries with high rates of grade repetition such as South Africa.

Thirdly, I present evidence of gender gaps in non-cognitive skills, specifically attitudes towards school and the learning process[5], and how these differences contribute to the pro-girl achievement gap in South Africa. Notably, I find that gender differences in non-cognitive skills may be an important contributing factor to South Africa's pro-girl advantage in PIRLS. This result is in accordance with findings from the international literature, and highlights the need for more research on the role of non-cognitive skills in contributing to South Africa's pro-girl advantage in reading achievement. Lastly, performing the

[5] See the definition of non-cognitive skills in Section 2 for the motivation behind including student attitudes under the umbrella of 'non-cognitive skills'.

decomposition analysis separately by school quintile allows me to uncover SES differences in both the magnitude and factors contributing to the pro-girl achievement gaps in PIRLS and TIMSS. I find that after accounting for students' age, the pro-girl achievement gap decreases with school socio-economic status, and the factors that contribute to the pro-girl gap differ across school socio-economic status.

The paper is structured as follows: Section 2 provides a brief review of the international literature on pro-girl achievement gaps, paying particular attention to studies that investigate the role of gender differences in student attitudes toward learning and school. Details of the estimation samples and key measures used in the decomposition analysis are presented in Section 3. Section 4 documents the magnitude of the pro-girl achievement gap across school quintiles in both PIRLS and TIMSS, and provides descriptive evidence of how this gap is related to gendered grade repetition patterns in the foundation phase (Grades 1-3). The results of the decomposition analysis which investigates potential sources of the pro-girl gap among students who are on-track in terms of age-for-grade are discussed in Sections 5 and the implications of these results are discussed in Section 6. Section 7 concludes.

2. Literature review

There is a vast literature demonstrating that learning outcomes are surprisingly gendered. Evidence from industrialised countries points to remarkable uniformity in gender achievement gaps in the primary school grades, which can be summarised quite simply: girls do better in reading and boys do better in mathematics (Cobb-Clark and Moschion, 2017). The evidence from developing countries, on the other hand, is more difficult to summarise, given much more variation in the magnitude and direction of gender achievement gaps across countries. For example, in a comparison of gender achievement gaps in four developing countries, Dercon and Singh (2013) find that Ethiopia and India exhibit a pro-boy advantage in Grade 6 mathematics achievement, while Vietnam exhibits a distinctly pro-girl advantage, and Peru shows no significant gender gap in mathematics achievement at this age. Similarly, Zuze (2015) presents evidence of variation in the magnitude of gender achievement gaps within the East African region, with Kenya and Tanzania exhibiting large pro-boy gaps in SACMEQ[6] Grade 6 mathematics achievement, and Uganda not exhibiting significant gender differences in achievement in the same assessment. Based on this evidence, Zuze (2015) concludes that gender issues are unique to countries, even those in the same geographic region, and the factors that contribute to gender achievement gaps are largely determined by the local context, both between and within countries.

Part of the difficulty in interpreting evidence of achievement gaps in developing countries lies in correcting for sample selection bias that results from gender differences in access to schooling. While

[6] The Southern and Eastern African Consortium for Monitoring Educational Quality, a standardized assessment conducted in 15 countries in southern and eastern Africa.

major progress has been made in terms of ensuring equal access to schooling – especially since reducing gender gaps disadvantaging girls became part of the UN's Millennium Development Goals in 2000 (Grant & Behrman, 2010) – in many developing countries access is still biased against girls. When analysing gender gaps in achievement, one therefore has to account for these differential access rates (see for example Grant & Behrman, 2010). While this is not the case in South Africa, which exhibits near-universal enrolment during the compulsory phase of schooling (that is, up to Grade 9) (Van der Berg and Hofmeyr, 2018), there is a different source of sample selection bias that may exaggerate observed gender gaps in achievement, namely differential rates of grade repetition by gender. Van der Berg *et al.* (2019) present a comprehensive account of grade repetition in South Africa, and find that boys are more likely than girls to repeat in virtually all grades. Importantly, they present evidence that boys' disadvantage in terms of grade completion already begins in Grade 1, and only becomes more pronounced as students progress through school. This results in more boys being overage – that is, older than they should be in a particular grade – than girls in almost all grades. Given that grade repetition is usually associated with weaker academic performance (Ikeda and García, 2014; Sunny *et al.*, 2017), gendered patterns of grade repetition in Grades 1-3 may cause a selection effect whereby a larger proportion of boys than girls in a given Grade 4 or 5 class are already "selected" to be weaker-performing, which would exaggerate pro-girl achievement gaps in PIRLS and TIMSS. In essence, this would mean that girls already outperform boys in the foundation phase (Grades 1-3) and that the achievement gaps observed in PIRLS and TIMSS are largely the result of a pro-girl advantage that accumulates over the course of the early grades. While investigating the sources of this gap in the early grades is beyond the scope of this paper, it is still useful to know how much of the observed pro-girl achievement gaps in PIRLS and TIMSS can be attributed to these gendered repetition patterns in the early grades. This question is therefore explored explicitly in the decomposition analysis.

The literature distinguishes between four broad categories of explanations for gender gaps in educational achievement (Wilsenach and Makaure, 2018): (i) biological, where girls' superior academic achievement is linked to evidence that girls develop the cognitive skills that underpin learning earlier than boys (Gierl *et al.*, 2003; Rosselli *et al.*, 2009; Andreoni *et al.*, 2019); (ii) parents' gender-specific expectations and investments (Kingdon, 2002; Entwisle, Alexander and Olson, 2007; Mencarini, Pasqua and Romiti, 2019); (iii) schooling, where it is argued that educational practices favour girls (Entwisle, Alexander and Olson, 2007); and (iv) gender differences in the acquisition of non-cognitive skills that support learning. Mounting evidence of the important role that non-cognitive skills play in determining educational outcomes more generally (Heckman, 2000; Almlund *et al.*, 2011; Heckman and Kautz, 2012; Diaz, Arias and Tudela, 2013; Garcia, 2013; Kautz *et al.*, 2014; Stankov and Lee, 2014; Egalite, Mills and Greene, 2016) has led to increased attention to potential gender differences in these skills in the achievement gap literature. The definition of the term 'non-cognitive skills' is the subject of ongoing debate in the economics of education literature (Duncan and Magnuson, 2011).

Following Farkas (2011), I maintain that student attitudes can be included under this umbrella insofar as they meet the criteria for non-cognitive skills offered by Garcia (2014: 6), namely:

> "traits that are not directly represented by cognitive skills or by formal conceptual understanding, but instead by socio-emotional or behavioural characteristics that are not fixed traits of the personality, and that are linked to the educational process, either by being nurtured in the school years or by contributing to the development of cognitive skills (or both)."

Existing evidence points to a pro-girl gap in student attitudes, including subject-specific self-efficacy beliefs (Kennedy, 2008; Popp *et al.*, 2014; McGeown *et al.*, 2015), engagement in lessons (Van de Gaer *et al.*, 2009; DiPrete and Jennings, 2012; McGeown *et al.*, 2015), reading enjoyment (Kennedy, 2008; Logan and Johnston, 2009; Marinak and Gambrell, 2010; Mol and Jolles, 2014), and mathematics enjoyment (Hemmings, Grootenboer and Kay, 2011). Studies in this strand have also considered gender differences in students' sense of belonging at school and the frequency with which bullying is experienced at school as potential sources of the pro-girl achievement gap, with existing evidence pointing to girls having a higher sense of school belonging (Goodenow, 1993; Sánchez, Colón and Esparza, 2005; Hughes, Myung and Allee, 2015) and being less likely to experience bullying at school than boys (Scheithauer *et al.*, 2006; Popp *et al.*, 2014).

It is important to note, however, that these distinctions between categories of explanations for gender gaps in educational outcomes - usually made for methodological reasons - are largely artificial in the sense that learning outcomes result from a combination of "overlapping spheres of influence" (Alexander, 2016: 18), making it nearly impossible to disentangle the multitude of factors that contribute to the gender achievement gap (DiPrete and Jennings, 2012; Cobb-Clark and Moschion, 2017). Importantly, two decades of research on the formation of skills (Heckman, 2006) has shown that developmental environments are crucial in shaping both cognitive and non-cognitive skills. This finding blurs the distinctions between the four categories of explanations for the gender achievement gap listed above, since we now know that children's cognitive (explanation (i)) and non-cognitive skills (explanation (iv)) are shaped jointly by genetics, their environments (explanation (ii)), and parental investments (explanation (iii)).

A number of authors have attempted to investigate how different spheres of influence interact to produce gender gaps in educational outcomes by evaluating these gaps separately for students at different points of the SES distribution. The consensus based on evidence from industrialised countries seems to be that pro-female gaps in educational outcomes are more pronounced among low-SES students (Bertrand and Pan, 2011; Legewie and DiPrete, 2012; Autor *et al.*, 2016; Mencarini, Pasqua and Romiti, 2019), with some studies finding evidence to suggest that pro-girl advantages in achievement are found *only* among socioeconomically disadvantaged students (see Entwisle, Alexander and Olson (2007) for a review of this literature). A number of potential reasons have been proposed for this evidence that gender achievement gaps tend to be more pronounced among socioeconomically disadvantaged children. These can broadly be grouped into two categories, namely (i) explanations that ascribe this phenomenon to SES differences in parents' and teachers' expectations of boys and girls, with parents and teachers tending to have lower expectations of low-SES boys – an effect which is absent among high-SES students (Entwisle, Alexander and Olson, 2007; Strand, 2010), and (ii) explanations that hinge on the notion that characteristics of boys' and girls' home and school environments are translated into educational outcomes in different ways. In particular, a number of authors present evidence to suggest that boys' educational outcomes are more sensitive to socioeconomic home disadvantage (Bertrand and Pan, 2011; Marcenaro–Gutierrez, Lopez–Agudo and Ropero-García, 2018; Mencarini, Pasqua and Romiti, 2019) and low-quality schools (Legewie and DiPrete, 2012; Autor *et al.*, 2016).

In summary, there are three important findings from the international literature regarding the nature and potential sources of gender gaps in educational outcomes that inform the research design of this study. Firstly, gender gaps differ across subjects, with girls typically outperforming boys in reading, while boys tend to have an advantage in mathematics. Secondly, there is evidence to suggest that gender gaps differ by SES, something that has received little attention in the South African literature on gender gaps in educational outcomes. Thirdly, potential gender differences in student attitudes are a likely source of South Africa's pro-girl gender gap in educational outcomes that have not yet been investigated in the local literature.

The aim of this paper is thus to contribute to our understanding of the magnitude and potential sources of the pro-girl achievement gap in South Africa by examining variation in this gap across school quintiles in two subjects, namely reading and mathematics, and to investigate whether student attitudes contribute to this gap. Evidence from the local literature suggests, however, that there may be gendered sample selection processes underlying the composition of any given class participating in international assessments such as PIRLS and TIMSS. Specifically, the fact that boys are more likely to be held back in the foundation phase may mean that the samples of boys participating in these assessments are already "selected" to be weaker-performing than girls. The analysis in this paper therefore attempts to answer two questions, namely (i) How much of the observed pro-girl achievement gaps in PIRLS and TIMSS can be attributed to gendered repetition patterns in the early grades?; and (ii) How much of this achievement gap can be attributed to observable differences between boys and girls, when comparing only boys and girls who are on-track in terms of age-for-grade?

3. Data

I make use of the most recent publicly available data from two international educational assessments that South Africa participates in, namely the 2016 round of the Progress in International Reading Literacy Study (PIRLS) for developing countries, PIRLS Literacy, and the Trends in Mathematics and Science Study (TIMSS) study for developing countries, TIMSS Numeracy, which was conducted in

2015.

3.1. Estimation samples

PIRLS Literacy 2016

PIRLS is an international large-scale literacy assessment conducted by the International Association of the Evaluation of Educational Achievement (IEA). PIRLS Literacy 2016 was administered by the Centre for Evaluation and Assessment (CEA) at the University of Pretoria. PIRLS 2016 employed a two-stage stratified cluster sampling design so that a nationally representative sample of schools was chosen according to province and the school's language of instruction in the foundation phase (Howie *et al.*, 2017). Within the sampled schools, classes were randomly selected for participation. Sampled classes thus constitute the second-stage sampling units. All students in sampled classes present on the day of the assessment participated in the assessments. In 2016 the realised PIRLS sample consisted of 12,810 Grade 4 students from 293 schools across South Africa. An interesting feature of South Africa's PIRLS data that has not received attention is the fact that the sample is not perfectly balanced in terms of gender – boys make up 51.8% of the sample. Unfortunately, the data contains some missing information in the student attitude measures. Since these variables constitute some of the main covariates of interest, students who had missing information on these measures were dropped from the sample. This resulted in 1,027 students (8% of students) being dropped from the original PIRLS sample. The sample used in my analysis therefore consists of 11,734 students from all 293 schools[7]. Boys were slightly more likely to have missing information on the student attitude measures, resulting in boys comprising 51.2% of the final estimation sample.

TIMSS Numeracy 2015

TIMSS Numeracy is also conducted by the IEA and was administered in South Africa by the Human Sciences Research Council (HSRC). TIMSS collects the same contextual information from students, parents, teachers and principal as PIRLS (Human Sciences Research Council, 2017). Students were sampled using the same two-stage stratified cluster sampling design as employed in PIRLS. The TIMSS 2015 realised sample consists of 10,932 Grade 5 students from 297 schools (51.6% male). The same missing data concerns present in PIRLS plague the TIMSS data, thus students with missing information on the student attitude variables were also dropped from the original TIMSS sample. This resulted in the deletion of 649 observations (6% of the original sample). The TIMSS sample used in the analysis that follows thus consists of 10,283 Grade 5 students (51.6% male) from all 297 schools.

[7] As a sensitivity check, the decomposition was also performed on the original PIRLS sample of 12,810 students and the original TIMSS sample of 10,932 students. Following Shepherd (2013), missing data on the student attitude variables were assigned the lowest value the variable could take on. The results from the main estimation (presented in Section 5 are robust to this alternative way of dealing with missing data in the student attitude variables. The results from the estimation on the original samples are presented in Table A14 of the Appendix.

3.2. Description of measures

Educational achievement measures

The PIRLS Literacy assessment consisted of a silent reading comprehension test administered in all South Africa's 11 official languages. The school language policy of South Africa is currently implemented in such a way that the language of learning and teaching (LOLT) for the vast majority of students is their home language in Grades 1-3, and from Grade 4 there is a LOLT switch to English for the remaining school years (Spaull and Kotze, 2015). By Grade 4, the majority of South African students would have had limited exposure to English, and consequently the comprehension test was administered in the school's LOLT in the foundation phase. The TIMSS Numeracy assessment tested fundamental mathematical knowledge, procedures, and problem-solving skills (Human Sciences Research Council, 2017) and was administered in English or Afrikaans. Both PIRLS and TIMSS test scores are standardised to have an international mean of 500 points and a standard deviation of 100 points, and these scores were standardised for each sample used in my analysis to have a mean of zero and a standard deviation of one for ease of interpretation of the multivariate results.

It is important to note that the PIRLS and TIMSS assessments differ markedly in terms of their relative difficulty. PIRLS was developed for a predominantly high-income country context (Spaull and Pretorius, 2019) and it is clear from South Africa's results that students found this assessment very challenging, with only 22% of students reaching the low international benchmark of 400 points. TIMSS Numeracy, on the other hand, was also developed for predominantly high-income countries, but countries could opt to administer the assessment to Grade 5 students, if they suspected that it would be too difficult for Grade 4 students. It is clear from South Africa's overall performance in TIMSS that students found the assessment less challenging than PIRLS, with 40% of students reaching the low international benchmark, though South African students were tested in Grade 5.

School SES measure

Following Spaull and Pretorius (2019), I calculate school SES as the average SES of all students in a school. Student SES was measured using information about eight possessions students indicated having in their homes. Principal components analysis (PCA) was used to derive an index from these variables in the PIRLS and TIMSS samples, respectively. As Spaull and Pretorius (2019) point out, this method is unlikely to create an accurate cardinal measure of wealth. However, since my purpose in creating an asset index are the same as theirs – to create an ordinal ranking of student wealth – I maintain, as they do, that an asset index created from the home possessions variables in PIRLS and TIMSS is the best measure of student wealth available. The PIRLS asset index has an alpha coefficient of 0.61, and the TIMSS asset index has an alpha coefficient of 0.63. Average school SES was calculated as the mean of this asset index at the school level, and this variable was used to split the schools in each sample into SES quintiles, from the poorest 20% of schools (Quintile 1) to the wealthiest 20% of schools (Quintile

5).

Student attitude measures

In addition to student assessment data, PIRLS and TIMSS also administered student background questionnaires that included a section aimed to measure student engagement and attitudes toward reading and mathematics, respectively. Students had to choose from a four-point Likert scale (from "disagree a lot" to "agree a lot") on a number of items aimed at quantifying three specific constructs, namely confidence in reading/mathematics, engagement in reading/mathematics lessons, and reading/mathematics enjoyment. Indices of each of these constructs were then created by aggregating across the different items that were intended to capture each construct, with scores on each index ranging between 1 (low) and 3 (high). Student questionnaires also included items aimed at quantifying students' perceptions of school climate and safety, with specific emphasis on students' sense of belonging at school and student bullying. Items included to measure student's engagement and attitudes and their sense of belonging at school were also measured with four-point Likert items (from "disagree a lot" to "agree a lot"). Scores on these items were aggregated to create an index of school belonging ranging from 1 (low) to 3 (high)[8]. Student bullying was measured with eight items that asked students to report how often they had experienced different types of bullying, with response options "Never or almost never", "A few times a year", "Once or twice a month", and "At least once a week"[9]. Scores on these items were also added up and converted to an index with values ranging from 1 to 3. Thus a score of 1 translates to "never or almost never", 2 infers "about monthly", and 3 infers "about once a week". For ease of interpretation of the multivariate results, I standardised the student attitude, engagement, belonging, and bullying indices to have a mean of zero and a standard deviation of one.

Grade repetition measure

Unfortunately, neither the PIRLS and TIMSS data include direct measures of whether a student has repeated a grade. As such, I use students' age as a proxy for grade repetition. I code this as a dummy variable which takes a value of 1 if a student is one or more years older than they would be if they were "on-track" in terms of age-for-grade.

School characteristics

The decomposition models include only two variables that are intended to capture school characteristics that should theoretically matter for student achievement, namely dummy variables indicating whether the school has a library and whether the school has at least one computer. This decision was informed by two considerations. Firstly, there is not enough overlap between the school and classroom

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[8] See http://timssandpirls.bc.edu/pirls2016/international-results/pirls/student-engagement-and-attitudes/ for details about the procedures followed when assigning scores to the student attitude variables.

[9] Responses to the individual questionnaire items, by gender and students' age, can be found in Tables A3-A13 of the Appendix.

characteristics captured in South Africa's PIRLS 2016 and TIMSS 2015 data, respectively, to allow for meaningful comparison of the relative contributions of the various school characteristics in each dataset to the observed gender gaps in achievement. Since one of the aims of this paper is to compare the relative importance of specific observable differences between boys and girls in explaining the pro-girl achievement gaps in these datasets, a decision was made to only include those school-level factors that are available in both datasets (namely the library and computer dummies). Secondly, I maintain that, given the high degree of overlap between student SES and school resources in South Africa (Spaull, 2013), meaningful information about school context is captured by my variable of school socio-economic status. That is, while I do not explicitly control for school characteristics in the multivariate analysis (apart from the library and computer dummies), variation in school characteristics is implicitly controlled for through the splitting of the samples into school quintiles and performing the decomposition analysis separately by school quintile.

Other covariates

In addition to student attitudes and age, I include a number of measures to capture individual characteristics and behaviours of students, including whether they attended preschool, the frequency with which they did homework (parent-reported), student SES (measured using the asset index described above), and province. Given a large extent of missing information on the parent-reported homework frequency variable, this variable was recoded as a dummy indicating whether parents reported their child did homework at least three times a week or not. Missing values were grouped with the reference category. Lastly, I include a dummy variable indicating whether the student wrote the test in their first language. This variable was derived from the student background questionnaire item that asked students about the frequency with which they spoke the language of the test at home. Students who answered "always" or "almost always" on this question were assigned a value of 1 on the "first language" variable.

3.3. Descriptive differences between boys and girls

Table 1 and Table 2 show differences between boys and girls in these observable characteristics, by school quintile, for the PIRLS and TIMSS samples, respectively. Table 1 presents evidence of statistically significant differences between boys and girls in PIRLS in all the observable characteristics included here, across virtually all school quintiles. The results that girls are more confident in their reading abilities, report more engaging teaching by their reading teachers, enjoy reading more, report a higher sense of school belonging, and report experiencing bullying less often than boys are in accordance with the evidence presented in a number of existing studies, as discussed in Section 2. The fact that girls do homework more often than boys (according to parent reports) suggests that in addition to girls having more positive attitudes toward reading and school more generally, girls are also more likely to exhibit behaviour that supports learning – such as doing homework.

In accordance with the existing literature, the results in Table 1 indicate that boys are more likely to be overage than girls in all school quintiles. In addition, the results in the table point to large differences in the proportions of overage students across school quintiles, with larger proportions of overage students in poorer schools. This result is in line with the findings of Van der Berg *et al.* (2019) that grade repetition is more common in the lower school quintiles. Importantly, the proportions of overage boys and girls in each sample roughly match repetition rates in the early grades reported in existing studies (see Branson, Hofmeyr and Lam (2014)). This constitutes evidence that being overage is a good proxy for grade repetition in the PIRLS and TIMSS samples.

The results in Table 1 also show that girls have significantly lower asset index scores than boys, that is, that girls come from poorer homes than boys, on average. This is an unexpected result since gender is usually assumed to be exogenously determined (Cobb-Clark and Moschion, 2017). The reason for the apparent pro-boy advantage in wealth most likely lies in the fact that some of the assets included in the PIRLS student background questionnaire may have a gendered dimension, whereby parents may be more likely to acquire certain assets, depending on the gender of their child. Table A1 in the Appendix reports gender differences in each of the home assets, and provides evidence that boys are more likely to report having almost all the assets included in the PIRLS student background questionnaire in the homes, with boys being especially more likely to report having a gaming station, internet access, and their own bedroom. Conversely, girls are more likely to report having a study desk and their own story books. These gender differences must be interpreted with caution, however, since the asset measures are likely to be subject to response bias, and, moreover, since the extent of this bias may differ by gender (for example, Engzell (2019) presents evidence of gender differences in the likelihood of over-reporting the number of books in the home). The fact that boys in PIRLS scored higher on the asset index could therefore indicate that the assets included in the student background questionnaire are not gender neutral, or that boys are more prone to overreporting on certain assets, or both[10].

Interestingly, there appears to be less stark gender differences in students' attitudes toward mathematics than is the case for reading: Table 2 shows that girls only consistently scored higher than boys in all school quintiles on the variable measuring students' sense of belonging at school – a general measure of student belongingness, which is not mathematics-specific. The lack of statistically significant gender differences in mathematics self-concept ("Confidence index") in four out of the five school quintiles is particularly noteworthy, since subject-specific self-concept is usually strongly related with achievement. It is noteworthy that girls are no more confident in their mathematics abilities than boys, despite outperforming boys in mathematics in almost all quintiles. The fact that girls in the South African

[10] Gender differences in student-reported home possessions should not bias the measures of school SES, since there are roughly equal numbers of boys relative to girls in each school quintile. Any gender bias in either the presence of certain assets in students' homes, or the extent of over- or under-reporting on these asset measures, is therefore expected to be uniform across school quintiles. The result that there are significant gender differences in the home possession variables in both PIRLS and TIMSS does, however, constitute a noteworthy finding that should be interrogated in future research.

TIMSS are not significantly more confident in their mathematics abilities despite outperforming boys in the assessment accords with evidence in the international literature (Tapia and Marsh, 2000; Bofah and Hannula, 2015), and points to potential internalised gender stereotypes that boys are "naturally" better at mathematics (Steele, 1997).

As is the case in PIRLS, girls in TIMSS report being bullied significantly less often than boys in all school quintiles, and do homework more often than boys, according to parent reports. Girls in TIMSS are also much less likely to be overage than boys, a result that is consistent across school quintiles. The same SES differences in the extent of overage students observed in PIRLS are observable in TIMSS, whereby students in poorer schools are much more likely to be overage than their counterparts in wealthier schools. Once again, this result is consistent with Van der Berg *et al.*'s (2019) finding that grade repetition is more prevalent in the lower quintiles. It is further interesting to note from Table 2 that the same pro-boy advantage in student wealth observed in PIRLS is not observable in TIMSS, where only boys in the bottom school quintile scored significantly higher than girls on the asset index[11]. This result reflects the fact that the assets included in the TIMSS student background questionnaire are less likely to differ by gender, and in this sense the asset index constructed from the TIMSS home possession variables is likely to be a better measure of student wealth than the asset index constructed from the PIRLS home possession variables. However, I maintain that both asset indices suffice as ordinal measures of student wealth[12].

The results in Table 2 further point to a clear SES dimension to gender differences in student attitudes in TIMSS, with girls in poorer schools generally scoring higher than boys on the student attitude measures, while there are fewer significant gender gaps in student attitudes in wealthier schools. This is an unexpected result which points to potential SES differences in the nature of the pro-girl gap in TIMSS mathematics achievement. This result is explored further in the decomposition analysis.

Considered together, the results from Table 1 and Table 2 point to an interesting result, namely that while girls have much more positive attitudes towards reading than boys, the same is not generally true for girls' attitudes towards mathematics. This constitutes a noteworthy finding, since it points to an element of domain specificity to gender differences in student attitudes toward learning, whereby the magnitude of these differences depends in part on the subject which is being assessed. This result is also explored further in the decomposition analysis.

[11] See Table A2 in the Appendix for responses to individual home possessions, by gender and school quintile.
[12] See footnote 10 on the previous page.

Table 1: Descriptive differences between boys and girls, by school quintile – PIRLS (Grade 4)

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5		Total	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Confidence index	-0.268	-0.065***	-0.110	0.025***	-0.111	0.064***	-0.034	0.149***	0.102	0.314***	-0.078	0.104***
Engagement index	-0.159	-0.009***	-0.184	0.070***	-0.091	0.114***	-0.034	0.209***	0.036	0.247***	-0.083	0.132***
Enjoyment index	-0.190	0.051***	-0.133	0.097***	-0.103	0.195***	-0.013	0.270***	-0.158	0.187***	-0.116	0.167***
Belonging index	-0.006	0.096**	-0.092	0.128***	-0.142	0.083***	-0.053	0.147***	-0.084	0.122***	-0.076	0.116***
Bullying index	-0.030	-0.126**	0.134	0.000***	0.171	-0.030***	0.071	-0.07***	-0.090	-0.237***	0.055	-0.093***
Overage	0.404	0.261***	0.412	0.240***	0.406	0.263***	0.388	0.248***	0.322	0.206***	0.386	0.243***
Homework	0.277	0.338***	0.379	0.486***	0.342	0.452***	0.250	0.346***	0.400	0.500***	0.331	0.426***
Asset index	-0.758	-0.800	-0.210	-0.341***	0.084	-0.076***	0.392	0.241***	0.856	0.708***	0.103	-0.022***
N	1,037	987	1,171	1,085	1,322	1,238	1,251	1,252	1,228	1,163	6,009	5,725
Proportion of N	51%	49%	52%	48%	52%	48%	50%	50%	51%	49%	51%	49%

Sources: Author's calculations from PIRLS 2016 (Reduced sample of 11,734 students (51% male)). Notes: All indices are standardised to have a mean of zero and a standard deviation of one. Asterisks indicate statistically significant gender differences at *p<0.10, **p<0.05. ***p<0.01. 'Homework' is a dummy variable indicating the proportion of students whose parents reported that they do homework at least three times a week.

Table 2: Descriptive differences between boys and girls, by school quintile - TIMSS (Grade 5)

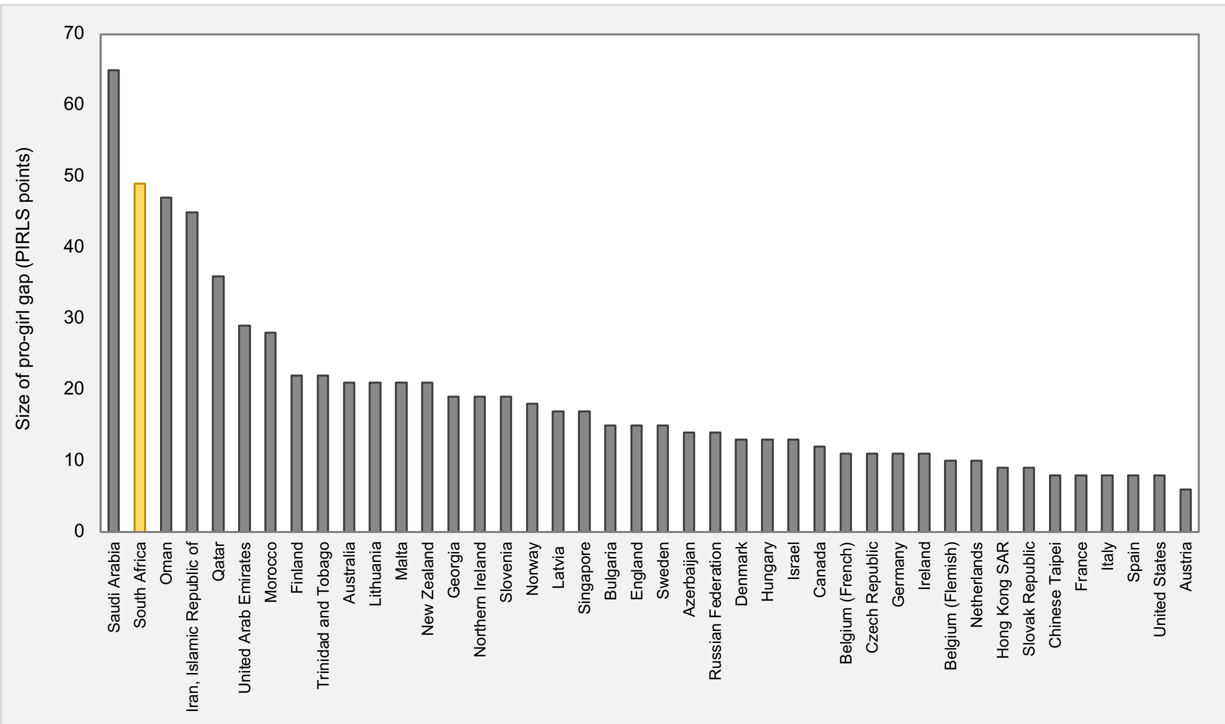
	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5		Total	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Confidence index	-0.212	-0.154	-0.211	-0.092***	-0.063	-0.028	0.065	0.048	0.386	0.325	-0.015	0.015
Engagement index	-0.230	-0.086***	-0.298	-0.100***	-0.019	0.057*	0.079	0.165**	0.209	0.239	0.053	0.055***
Enjoyment index	-0.247	-0.143**	-0.208	-0.041***	0.031	0.069	0.078	0.147	0.137	0.149	-0.038	0.040***
Belonging index	-0.193	-0.033***	-0.206	-0.020***	-0.066	0.068***	0.067	0.152**	0.053	0.175**	-0.067	0.069***
Bullying index	0.179	0.054**	0.317	0.111***	0.130	-0.080***	0.000	-0.169***	-0.225	-0.388***	0.088	-0.090***
Overage	0.425	0.267***	0.376	0.190***	0.408	0.253***	0.302	0.186***	0.244	0.119***	0.352	0.204***
Homework	0.520	0.550	0.554	0.630****	0.500	0.581***	0.581	0.675***	0.676	0.749***	0.562	0.636***
Asset index	-0.533	-0.635**	-0.169	-0.209	0.062	0.021	0.312	0.326	0.791	0.821	0.091	0.060
N	904	898	1,089	1,051	1,156	1,129	1,187	1,093	882	894	5,218	5,065
Proportion of N	50%	50%	51%	49%	51%	49%	52%	48%	50%	50%	51%	49%

Sources: Author's calculations from TIMSS Numeracy 2015 (Reduced sample of 10,283 students (51% male)). Notes: All indices are standardised to have a mean of zero and a standard deviation of one. Asterisks indicate statistically significant gender differences at *p<0.10, **p<0.05. ***p<0.01. 'Homework' is a dummy variable indicating the proportion of students whose parents reported that they do homework at least three times a week.

4. The magnitude of the pro-girl achievement gap in reading and mathematics

The magnitudes of the pro-girl achievement gaps among participating countries in PIRLS and TIMSS are shown in Figure 1 and Figure 2, respectively. Figure 1 shows that South Africa had the second-largest pro-girl gap in Grade 4 reading across participating countries. Moreover, South Africa's pro-girl gap is around *four times* larger than the average pro-girl gap out of all countries participating in the 2016 round of PIRLS (49 points compared with 12 points) (Mullis *et al.*, 2017). The magnitude of this gap implies that South African girls are a full year of learning ahead of boys in terms of reading achievement by Grade 4 (Spaull and Makaluza, 2019)[13]. In terms of mathematics achievement, Figure 2 shows that although South Africa's pro-girl achievement gap in TIMSS was much smaller than the pro-girl gap in PIRLS, the magnitude of this pro-girl advantage was the fifth-largest out of the 47 countries participating in TIMSS 2015. Moreover, as the evidence presented in Section 2 makes clear, this pro-girl gap is highly unusual even by regional comparison. These results suggest that girls in South Africa have a unique advantage in primary school reading and mathematics achievement that warrants further investigation.

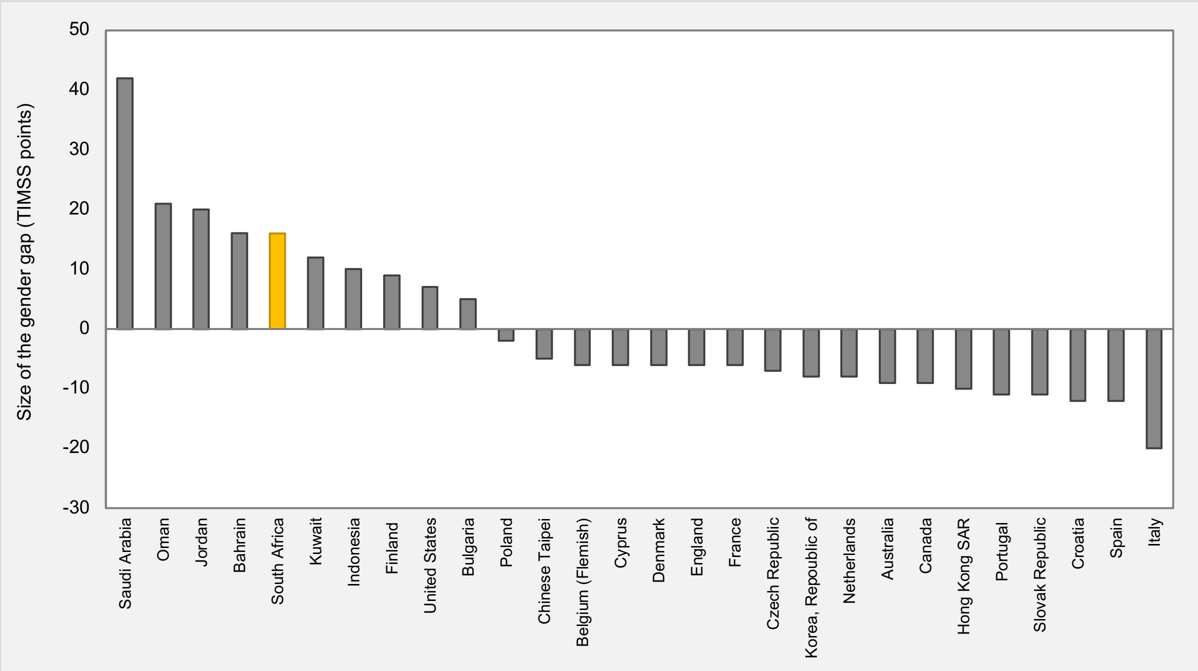
Figure 1: Magnitude of the pro-girl gap in PIRLS Reading (2016), by country



Source: Mullis et al. (2016). Notes: Only countries with statistically significant gender gaps in reading are shown. PIRLS scores are standardised to have a standard deviation of 100 points, thus 10 PIRLS points is equal to 10% of a standard deviation.

[13] This is an estimate based on Evans and Yuan's (2019) methodology for converting standard deviations in PIRLS scores to equivalent years of schooling, where the increase in test scores between two consecutive grades is assumed to be equal to the amount of learning that takes place in a year. In South Africa, the Grade 5 PIRLS score in 2006 was 0.36 standard deviations higher than the score of Grade 4 learners who wrote the same test (Van der Berg and Gustafsson, 2019), thus 0.36 standard deviations in 2006 PIRLS scores is estimated to be roughly equal to one year of learning in South Africa. Taking into account improvements in the amount of learning that takes place in a year over the period 2011-2016 (Van der Berg and Gustafsson, 2019), half a standard deviation can be considered equivalent to one year of learning in terms of South Africa's PIRLS scores (Spaull and Makaluza, 2019).

Figure 2: Magnitude of the pro-girl gap in TIMSS Mathematics (2015), by country



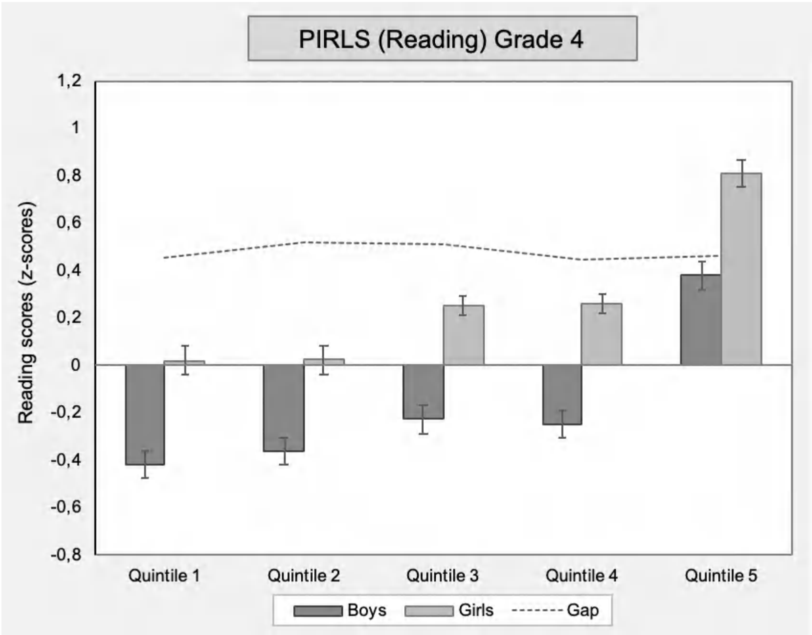
Source: Mullis et al. (2016). Notes: Negative values indicate a pro-boy gap. Only countries with statistically significant gender gaps in mathematics are shown. TIMSS scores are standardised to have a standard deviation of 100 points, thus 10 TIMSS points is equal to 10% of a standard deviation.

Figure 3 and Figure 4 show the magnitudes of South Africa's pro-girl gap (illustrated by the dotted line) by school quintile in PIRLS and TIMSS, respectively. It is clear from Figure 3 that the magnitude of the pro-girl gap in PIRLS is invariant across school quintiles. The absence of SES differences in the magnitude of the pro-girl gap in reading achievement is in itself a noteworthy result, given findings from the international literature that pro-girl gaps in reading achievement are more pronounced among low-SES students (Entwisle, Alexander and Olson, 2007). This result is therefore suggestive of potential differences in the interaction between SES and gender in producing reading outcomes in South Africa as compared to the findings from industrialised countries. This is explored further in the multivariate analysis. By contrast, Figure 4 shows that the magnitude of South Africa's pro-girl gap in TIMSS mathematics achievement decreases with school quintile. Importantly, the size of the pro-girl achievement gap in mathematics decreases to insignificance in Quintile 5 schools. This result is consistent with that of Zuze & Beku (2019), who also find a larger pro-girl gap in Grade 5 TIMSS results in no-fee (Quintile 1-3) schools compared to fee-paying (Quintile 4 and 5) schools.

The last result that is worth emphasising in Figure 3 and Figure 4 is that within gender groups, there are starker inequalities by school wealth in mathematics outcomes compared to reading outcomes. For example, girls in Quintile 5 schools outperformed girls in Quintile 1 schools by 1.4 standard deviations in mathematics (Figure 4), while this gap was 79% of a standard deviation in reading scores (Figure 3). Similarly, boys in Quintile 5 schools achieved mathematics scores 1.5 standard deviations above boys in Quintile 1 schools, while this gap was 80% of a standard deviation in reading test scores. These results suggest that controlling for gender, school SES is more predictive of TIMSS mathematics scores than

PIRLS reading scores. That is not to say, however, that the SES differences in reading scores are not themselves worth emphasising. The magnitudes of the gaps in PIRLS reading achievement across school quintiles indicate that controlling for gender, students in Quintile 5 schools are more than a year of learning ahead of students in Quintile 4 schools[14], a result that has received much attention in local education research (see for example Spaull and Makaluza (2019)), and warrants re-emphasising here.

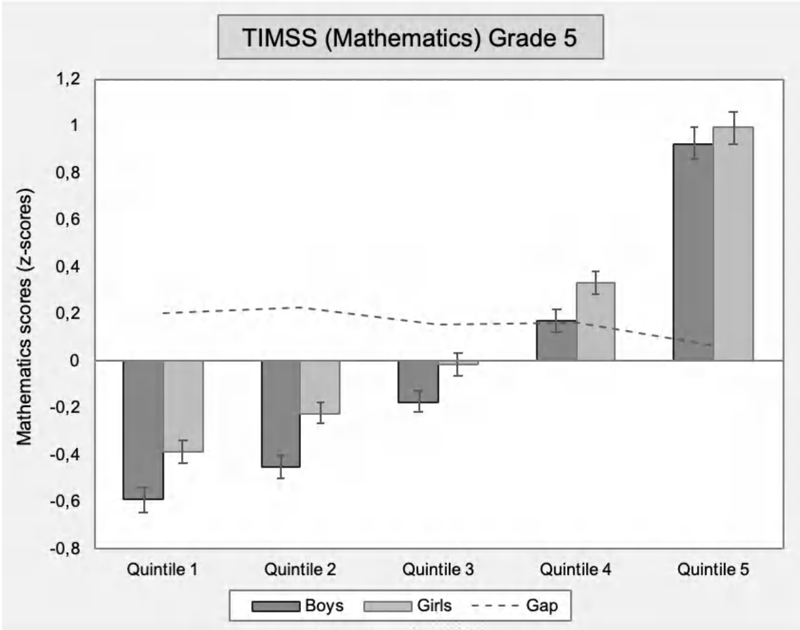
Figure 3: Magnitude of the pro-girl achievement gap in PIRLS by school quintile



Source: Author's calculations from PIRLS 2016 (Reduced sample of 11,734 students (51% male)). Note: Reading test scores are standardised to have a mean of zero and a standard deviation of one.

[14] See footnote 13 on page 15.

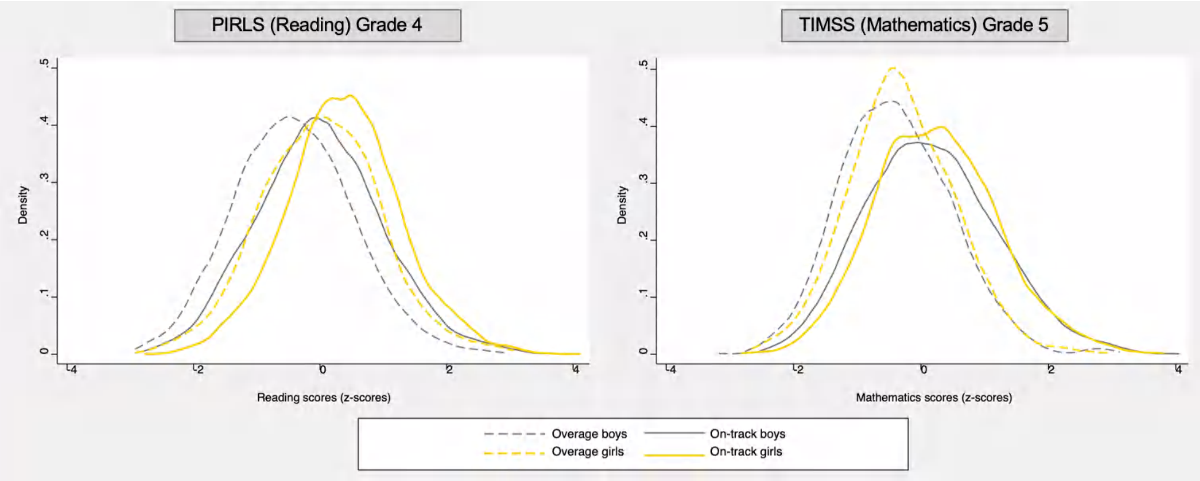
Figure 4: Magnitude of the pro-girl achievement gap in TIMSS by school quintile



Source: Author's calculations from TIMSS Numeracy 2015 (Reduced sample of 10,283 students (52% male)). Note: Mathematics test scores are standardised to have a mean of zero and a standard deviation of one.

The evidence presented in Section 3.3 of higher proportions of boys being overage in both PIRLS and TIMSS points to a selection effect whereby any given Grade 4 or 5 class consists of a larger proportion of boys than girls who have repeated a grade. Since grade repetition is associated with weaker academic performance, this implies that any given Grade 4 or 5 class consists of a larger proportion of boys than girls who have been 'selected' to be weaker performers. Given this situation, it is useful to assess whether a pro-girl achievement gap remains after controlling for students' age, i.e. whether there is still a pro-girl gap amongst those who have not repeated. To this end, Figure 5 plots the distributions of test scores in PIRLS and TIMSS for overage and on-track learners, by gender. The figure shows that in TIMSS (the graph on the right-hand side of the figure), the test score distributions of on-track boys and girls (the solid lines) are nearly identical. That is, there is no pro-girl achievement gap in TIMSS when considering only students who are on-track in terms of age. This provides strong evidence in support of the hypothesis that the observed pro-girl achievement gap in TIMSS can be attributed to a 'repetition effect', whereby the fact that boys are more likely to be weaker performers in the early grades translates into a pro-girl advantage in mathematics achievement in Grade 5. By contrast, the PIRLS test score distributions plotted on the left-hand side of Figure 5 reveal a remaining pro-girl achievement gap, even when comparing only students who are on-track in terms of age (the solid lines). This suggests that unlike in TIMSS, girls still outperform boys in PIRLS reading achievement, even when comparing only girls and boys who are in the correct grade-for-age.

Figure 5: PIRLS and TIMSS scores by age and gender

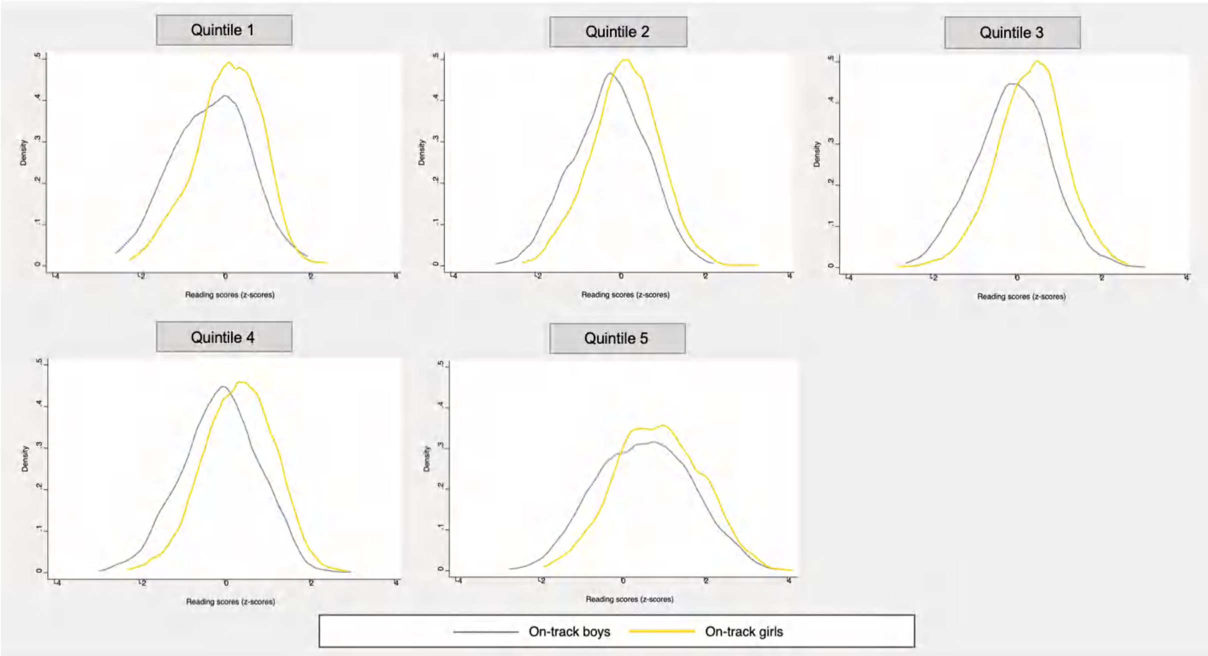


Sources: Author's calculations from PIRLS 2016 (Reduced sample of 11,734 students (51% male)) and TIMSS Numeracy 2015 (Reduced sample of 10,283 students (52% male)). Reading and mathematics test scores are standardised to have a mean of zero and a standard deviation of one.

Given the evidence from Table 1 and Table 2 that the proportion of overage students differs across school quintiles, the achievement distributions plotted in Figure 5 may be masking important variation in the relationship between students' age and achievement in PIRLS and TIMSS by school quintile. To determine whether the achievement distributions plotted in Figure 5 hold across school quintiles, PIRLS and TIMSS test score distributions by gender and school quintile are plotted in Figure 6 and Figure 7, respectively, this time only for students who are on-track in terms of age. Figure 6 shows that the magnitude pro-girl achievement gap among on-track students in PIRLS differs by school quintile, with a more pronounced gap observed in poorer schools. It is interesting to note that despite this variation, a pro-girl gap is observable in all school quintiles, even when restricting the sample to students who are on-track in terms of age. This constitutes evidence that the result presented in Figure 5 of a large remaining pro-girl gap in PIRLS reading achievement even among on-track students holds across all school quintiles.

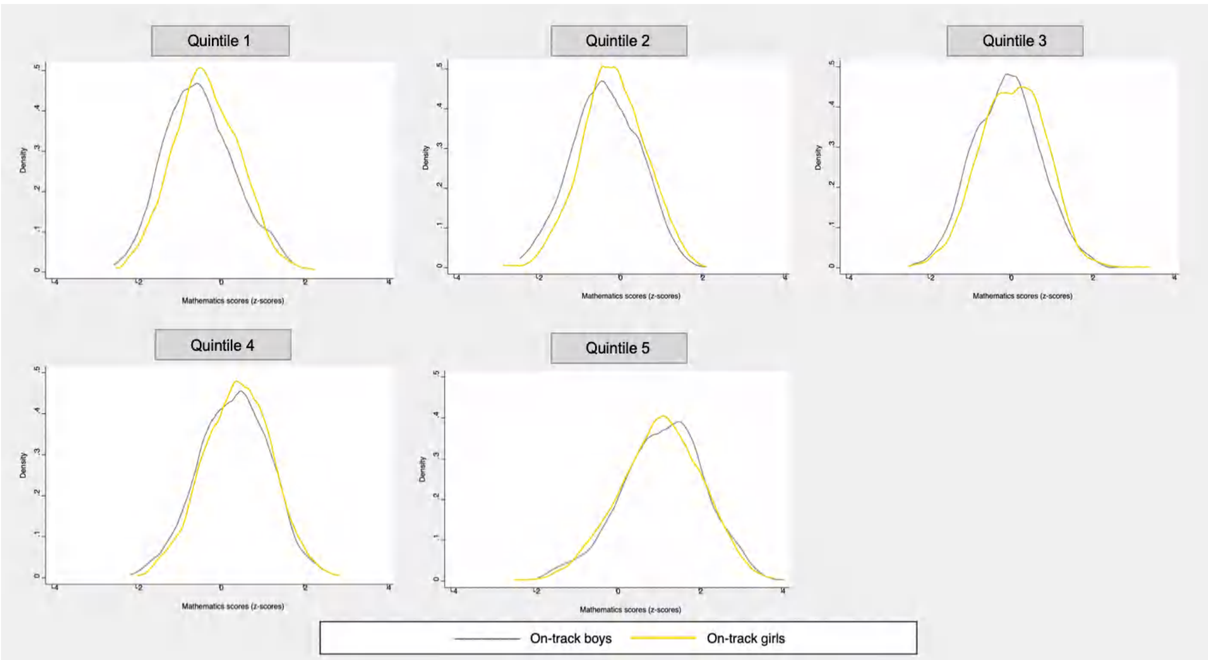
Interestingly, Figure 7 points to more variation across school quintiles in the pro-girl achievement gap among on-track students in TIMSS than is the case for PIRLS, with girls' Grade 5 mathematics test score distributions lying slightly to the right of boys' in Quintiles 1-3, and Quintile 4 and 5 boys' and girls' distributions being almost identical. This result, in combination with the results presented in Figure 6, suggests there may be SES differences in the relative contribution of students' age to the observed pro-girl achievement gaps in both PIRLS and TIMSS. Specifically, the fact that a large pro-girl gap is observable among on-track students in poorer schools, but that there seems to be almost no gender gap among on-track students in Quintile 4 and 5 students in TIMSS, suggests that the contribution of the 'overage' variable to the observed pro-girl achievement gap is relatively *larger* in wealthier schools. This is an unexpected result, since one would expect the contribution of being overage to the pro-girl achievement gap to be larger in poorer schools where grade repetition is more common. This result is explored further in the decomposition analysis that follows.

Figure 6: Distribution of PIRLS scores by gender and school quintile (on-track students)



Sources: Own calculations from PIRLS 2016. Notes: Reading test scores are standardised to have a mean of zero and a standard deviation of one. The test score distributions of on-track students are statistically significantly different from overage students at $p<0.01$ in all school quintiles (according to Kolmogorov-Smirnov tests of equality of distribution functions).

Figure 7: Distribution of TIMSS scores by gender and school quintile (on-track students)



Sources: Own calculations from TIMSS Numeracy 2015. Notes: Mathematics test scores are standardised to have a mean of zero and a standard deviation of one. The test score distributions of on-track students are statistically significantly different from overage students at $p<0.01$ in Quintiles 1, 2, and 3 (according to Kolmogorov-Smirnov tests of equality of distribution functions).

5. The sources of the gender achievement gap

5.1. The decomposition approach

Decomposition analysis has long been used by labour economists to identify the relative importance of various factors that contribute to gender, race or other gaps in labour market outcomes (Cobb-Clark and Moschion, 2017). More recently, a number of economists of education have used this approach to examine disparities in learning outcomes by, for example, urban-rural status (Burger, 2011), as well as gender (Kingdon, 2002; Cobb-Clark and Moschion (2017). In essence, this approach allows one to separate gender gaps into two components: (i) The component that can be explained due to differences in observable characteristics of males and females; and (ii) The unexplained component. My aim is to decompose the pro-girl gaps in achievement in both PIRLS and TIMSS into these two components. Formally, assuming a linear model of achievement, boys' and girls' test scores can be expressed as

$$\bar{T}_G^j = \bar{X}_G \hat{\beta}_G^j + \bar{\varepsilon}_G, \qquad \bar{\varepsilon}_G = 0; G \in (M, F) \tag{1}$$

where $\bar{T}_G^j$ denotes the mean test score of students of gender G (male (M) or female (F)) in subject j, $\bar{X}_G$ denotes the mean endowments (observable characteristics) of students of that gender, $\hat{\beta}_G^j$ denotes the coefficients on those endowments (that is, how those endowments are translated into test scores) for each gender and in each subject, and $\bar{\varepsilon}_G$ denotes the error term, which we assume to be zero. The gender gap in test scores can therefore be expressed as

$$\bar{T}_M^j - \bar{T}_F^j = \bar{X}_M \hat{\beta}_M^j - \bar{X}_F \hat{\beta}_F^j \tag{2}$$

I adopt Cobb-Clark and Moschion's (2017) approach of introducing a gender neutral coefficient vector ($\hat{\beta}_P^j$) to determine the contribution of the gender differences in endowments such that

$$\bar{X}_M \hat{\beta}_M^j - \bar{X}_F \hat{\beta}_F^j = (\bar{X}_M^j - \bar{X}_F^j)\, \hat{\beta}_P^j + \{\bar{X}_M^j(\hat{\beta}_M^j - \hat{\beta}_P^j) + \bar{X}_F^j(\hat{\beta}_P^j - \hat{\beta}_F^j)\} \tag{3}$$

where $\hat{\beta}_P^j$ is the coefficient from a pooled ordinary least squares regression of test scores on the full set of covariates over both males and females, and $\hat{\beta}_M^j$ and $\hat{\beta}_F^j$ are coefficients from separate regressions for males and females, respectively (Jann, 2008b). Thus the first term on the right-hand side of equation (3) is the explained component of the gender gap in test scores, that is, the difference in boys' and girls' test scores that arises because boys and girls have different endowments of the characteristics that matter for achievement (the 'endowment effect'). These characteristics are evaluated (i.e. weighted) using the vector of gender-neutral responses ($\hat{\beta}_P^j$) (Jann, 2008). The second term on the right-hand side of equation (3) is the unexplained component of the gender gap (the 'response effect'). This term can be interpreted as the part of the gender gap that arises because boys' and girls' endowments are not translated into test scores in a gender-neutral way (Cobb-Clark and Moschion, 2017). However, given that this interpretation requires the strong assumption that all factors that matter for achievement are included in the model (Jann, 2008), the coefficients on the covariates contributing to the unexplained component should be interpreted with caution.

To account for the potential sample bias resulting from different proportions of boys and girls being overage in both PIRLS and TIMSS, I conduct two decomposition analyses: One using each full PIRLS and TIMSS sample, and one using only the students in each dataset that are in the appropriate grade for their age. Conducting two decomposition analyses allows me to first assess the contribution of being overage (that is, having repeated at least a year) to the observed pro-girl achievement gaps in PIRLS and TIMSS, and then to investigate whether there are differences in observable characteristics between boys and girls contributing to the pro-girl achievement gap that remain when considering only "on-track" students in both datasets.

5.2. Sources of the pro-girl achievement gap

The results from the set of first decompositions are presented in Table 3 and Table 4. Since the aim of the first decomposition is to determine how much of the pro-girl gap in both datasets can be explained by gender differences in the proportion of overage students, only these results are reported in the tables[15]. The tables show boys' and girls' average standardised PIRLS and TIMSS scores and the magnitude of the gender gap in test scores, by school quintile. Negative values indicate a pro-girl advantage. The share of the gender gap in test scores attributable to differences in boys' and girls' characteristics (the 'endowment effect') is reported in the "Explained" row. Differences between boys and girls in how endowments are translated into achievement (the 'response effect') are reported in the "Unexplained" row. Figure 8 and Figure 9 show the results from Table 3 and Table 4 graphically. The dark grey bars represent the size of the endowment effect as a proportion of the total gender gap (the dotted lines in the figures), while the light grey bars represent the proportion of the gender gap that is explained by the dummy variable indicating whether students are overage[16]. For example, the explained component of the pro-girl gap in Quintile 1 schools in PIRLS is equal to 0.135, which constitutes 27% of the total gender gap (0.503) in Quintile 1 schools – the first dark grey bar in Figure 8. The coefficient on the "overage" dummy among Quintile 1 students is 0.036, which is 7% of the total gender gap – the first light grey bar in Figure 8.

[15] The detailed results from the first set of decompositions are reported in A15 and A16 of the Appendix.

[16] Only statistically significant components are plotted. The explained component and the contribution of 'overage' to the gender gap in quintile 5 schools in TIMSS are not plotted since there is no statistically significant gender achievement gap among these students.

Table 3: Selected results from the first decomposition (Includes overage students): PIRLS (Grade 4)

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Gender gap	-0.503***	-0.385***	-0.493***	-0.556***	-0.397***
	(0.051)	(0.027)	(0.031)	(0.029)	(0.041)
Boys' average	-0.457***	-0.415***	-0.234***	-0.274***	0.586***
	(0.062)	(0.045)	(0.047)	(0.050)	(0.100)
Girls' average	0.046	-0.030	0.259***	0.282***	0.984***
	(0.054)	(0.029)	(0.034)	(0.043)	(0.089)
Explained	-0.135***	-0.161***	-0.196***	-0.200***	-0.168***
	(0.025)	(0.014)	(0.022)	(0.022)	(0.031)
Unexplained	-0.368***	-0.224***	-0.296***	-0.356***	-0.230***
	(0.043)	(0.029)	(0.027)	(0.032)	(0.031)
Overage	-0.036***	-0.040***	-0.047***	-0.038***	-0.031***
	(0.010)	(0.008)	(0.009)	(0.006)	(0.008)
N	2,024	2,256	2,560	2,503	2,391

Notes: The decompositions include all the controls described in Section 3.2, but are not reported here. See Table A15 of the Appendix for the full list of controls and the detailed results. Standard errors are calculated at the school level and reported in parentheses.
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

Table 4: Selected results from the first decomposition (Includes overage students): TIMSS (Grade 5)

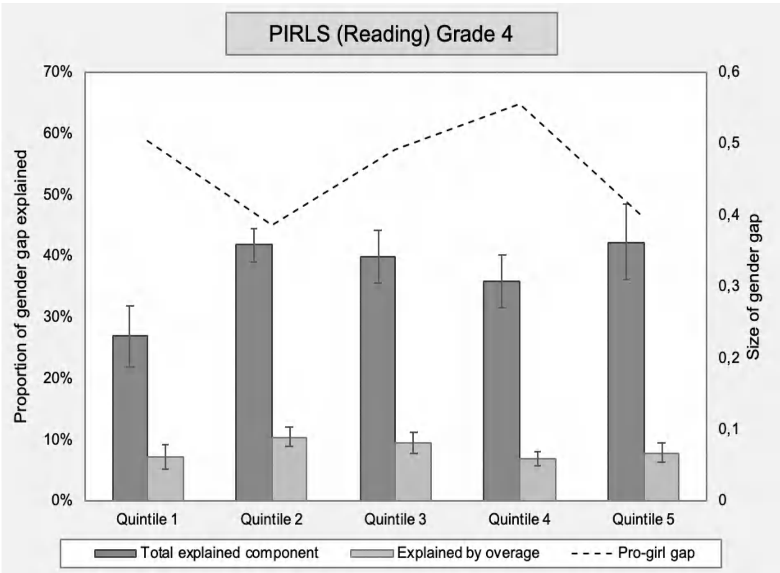
	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Gender gap	-0.216***	-0.209***	-0.223***	-0.156***	-0.010
	(0.062)	(0.032)	(0.026)	(0.026)	(0.073)
Boys' average	-0.611***	-0.517***	-0.281***	0.177***	0.956***
	(0.081)	(0.040)	(0.030)	(0.044)	(0.081)
Girls' average	-0.395***	-0.309***	-0.058	0.333***	0.966***
	(0.053)	(0.043)	(0.031)	(0.040)	(0.102)
Explained	-0.044**	-0.120***	-0.072***	-0.089***	-0.087
	(0.018)	(0.020)	(0.014)	(0.022)	(0.053)
Unexplained	-0.172**	-0.088***	-0.151***	-0.066***	0.077
	(0.065)	(0.025)	(0.027)	(0.014)	(0.054)
Overage	-0.014	-0.057***	-0.031***	-0.037***	-0.053***
	(0.008)	(0.008)	(0.006)	(0.008)	(0.015)
N	1,802	2,084	2,207	2,280	1,774

Notes: The decompositions include all the controls described in Section 3.2, but are not reported here. See Table A16 of the Appendix for the full list of controls and the detailed results. Standard errors are calculated at the school level and reported in parentheses.
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

The results presented in Figure 8 and Figure 9 indicate that on average across school quintiles, around 40% of the pro-girl gap in PIRLS can be explained by gender differences in the observable characteristics included in the decomposition model, while this proportion is 50% for the pro-girl gap in TIMSS. Importantly, the unexplained component of the gender gap (the 'response effect') is larger than the explained component (in all school quintiles in PIRLS, and in Quintiles 1 and 3 in TIMSS). In other words, girls have an advantage both in terms of their endowments of the characteristics considered here, as well as in terms of how those endowments are transformed into achievement, with the latter effect dominating the former in most cases. Since the focus of the first set of decompositions is the contribution of the 'overage' variable to the explained component of the gender gap, I return to consideration of the relative sizes of the explained and unexplained components in my discussion of the results of the second set of decompositions.

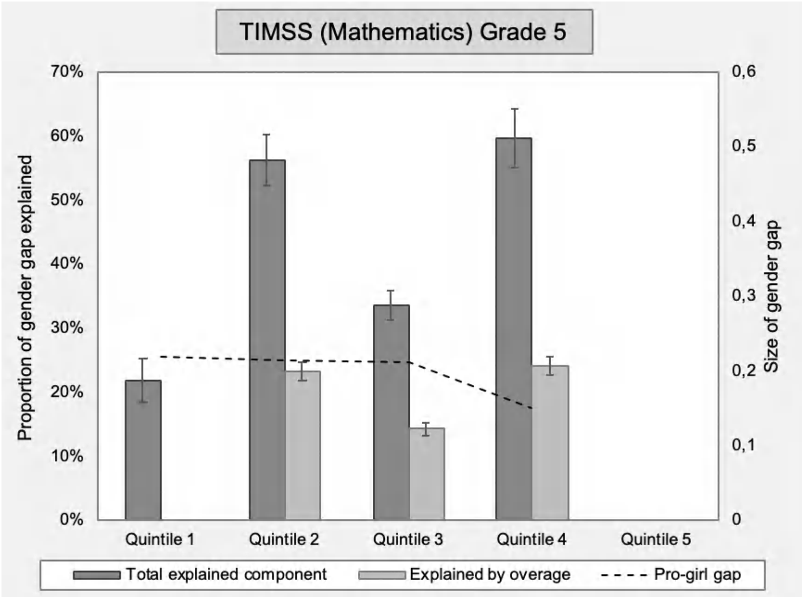
The results from the first decomposition further confirm the descriptive results presented in Section 4 of the importance of gendered patterns in grade repetition in the early grades in accounting for South Africa's pro-girl advantage in Grade 4 reading and Grade 5 mathematics achievement: The 'overage' variable emerges as significantly contributing to the pro-girl achievement gap across virtually all school quintiles in both PIRLS and TIMSS. Interestingly, however, it is clear from Figure 8 and Figure 9 that the contribution of the overage variable to the explained components of the gender gaps in both datasets is relatively small – around 10% in PIRLS and roughly 20% in TIMSS. This suggests that while gender differences in the proportions of students who are overage do explain part of the pro-girl achievement gaps in both PIRLS and TIMSS, a large part of this gap can be explained by differences between boys and girls in other observable characteristics. This result is explored further in the second set of decompositions.

Figure 8: Magnitude of the explained component of the gender gap in PIRLS, by school quintile



Source: Author's calculations from PIRLS 2016 (Reduced sample of 11,734 students (51% male)).

Figure 9: Magnitude of the explained component of the gender gap in TIMSS, by school quintile



Source: Author's calculations from TIMSS Numeracy 2015 (Reduced sample of 10,283 students (52% male)). Notes: No "overage" component plotted for Quintile 1 schools since the overage variable does not significantly contribute to the explained component of the gender gap in these schools. No components plotted for Quintile 5 schools since the gender achievement gap among students in these schools is not statistically significant.

The results of the second set of decompositions are presented in Table 5 and Table 6. The top panels show boys' and girls' average standardised test scores and the magnitude of the gender gap in test scores, by school quintile. Negative values indicate a pro-girl advantage. The share of the gender gap in test scores attributable to differences in boys' and girls' characteristics (differences in endowments) are presented in the "Explained" columns of the tables. The share of the gender gap attributable to differences between boys and girls in the way endowments are translated into achievement are reported in the "Unexplained" columns. For example, the negative and significant coefficients on the "Confidence index" across all school quintiles in PIRLS (Table 5) indicate that girls have higher confidence in reading than boys, and that this difference in confidence contributes significantly to the gender gap in reading scores in all quintiles. The lack of a significant response effect in student confidence across quintiles indicates that there are no gender differences in how given endowments of confidence are translated into PIRLS test scores. The magnitudes of the explained components are presented graphically in Figure 10 and Figure 11, where the yellow bars represent the explained component (endowment effect) as a proportion of the total gender gap (the dotted line). The grey bars in Figure 10 represent the magnitudes of the pro-girl advantage in endowments of student attitudes, expressed as a proportion of the gender gap. Differences in endowments of student attitudes are not plotted in Figure 11, since these differences are not statistically significant (see Table 6).

The first noteworthy result from the second set of decompositions is that a statistically significant pro-girl advantage remains across all school quintiles in PIRLS, and Quintiles 1-4 in TIMSS, even when accounting for gendered repetition patterns by limiting the sample to only students that are in the appropriate grade for their age. While the magnitude of the gender gap decreases in almost all school quintiles in PIRLS (with the exception of Quintile 1), the remaining pro-girl achievement gap remains large, suggesting that girls' advantage in achievement in the Foundation Phase and consequently lower overage proportion only partially accounts for South Africa's unusually large pro-girl achievement gap in PIRLS. A similar result emerges in the TIMSS data, whereby restricting the sample to exclude overage students reduces the magnitude of the gender in Quintiles 1-4, but a significant pro-girl achievement gap remains.

The unshaded bars in Figure 11 indicate that the explained component of the pro-girl gap in TIMSS mathematics scores is not statistically significant in either Quintile 1 or Quintile 4, a noteworthy result. This suggests that none of the observable characteristics included in the model contribute meaningfully to the observed pro-girl achievement gap in Quintiles 1 and 4 in TIMSS – that is, boys and girls in these school quintiles do not differ in their endowments of the characteristics that matter for mathematics achievement. By contrast, the explained component of the gender gap in PIRLS remains significant across all school quintiles, even after limiting the sample to on-track students. Importantly, the size of the endowment effect increases with school socio-economic quintile, from 19% in Quintile 1 to around 30% in Quintiles 2-5 (Figure 10). This points to SES differences in the nature of the pro-girl achievement gap that remain after restricting the sample to only students who are on-track in terms of age, with the observable characteristics considered explaining a larger proportion of the gender gap in wealthier schools.

The unexplained components are statistically significant in all school quintiles with a significant gender gap in both PIRLS and TIMSS. This is a noteworthy result, since it suggests that there is something about the way endowments are translated into achievement that differs between boys and girls in both PIRLS and TIMSS. The results from the second set of decompositions therefore suggest that whereas girls have both more endowments *and* higher returns to those endowments in PIRLS, the pro-girl gap in TIMSS is mostly driven by girls' higher returns to endowments. Given the well-cited issues with interpreting individual coefficients on the unexplained component (Jann, 2008), however, we will refrain from placing too much emphasis on these coefficients. The main result here is that the second set of decompositions constitute evidence of gender differences in both endowments and the returns to endowments in PIRLS, whereas the remaining pro-girl gap in TIMSS is largely due to gender differences in returns to endowments.

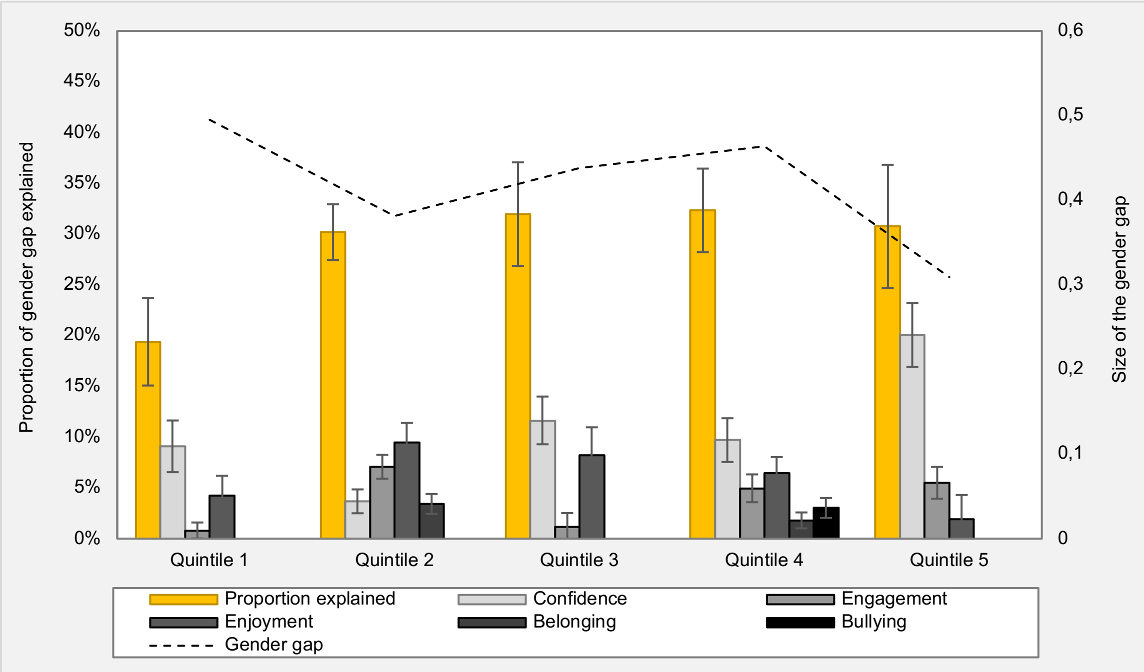
In terms of gender differences in student attitudes, the results presented in Figure 10 suggest that girls' higher endowments of these characteristics contribute significantly to the pro-girl achievement gap, even when restricting the sample of students to only those who are on-track in terms of age. The same is not true for TIMSS (Table 6), where even in the two quintiles where the explained component of the gender gap is statistically significant (Quintiles 2 and 3), none of the subject-specific student attitudes contribute consistently to the gender achievement gap in both quintiles.

It is further interesting to note that in addition to SES differences in the magnitude of the gender gap, the results in Figure 10 point to significant variation across school quintiles in the contribution of student attitudes to the pro-girl achievement gap in PIRLS. For example, girls' higher reading self-concept explains around 10% of the gender achievement gap in Quintile 1-4 schools, and twice as much (20%) in Quintile 5 schools. This is a noteworthy result, since it points to variation in the association between student attitudes and learning outcomes by school socio-economic context. The interaction between student attitudes and SES has received little attention in both the local and the international literature, and the findings presented here suggest it is likely to be a fruitful avenue for future attempts to understand the role of these factors in determining learning outcomes, especially in developing country contexts.

In addition to attitudes towards reading and school, girls also reported doing homework more frequently than boys in all five school quintiles in PIRLS, as well as in the two quintiles with a significant explained component in TIMSS (Quintiles 2 and 3). Interestingly, the fact that girls report doing homework more often than boys accounts for a larger proportion of the explained component of the pro-girl gap in reading among Quintile 5 students (11%) than is the case for students in poorer school quintiles (for example, 4% among students in Quintile 1 schools). The result that girls report doing homework more frequently and that this contributes to the pro-girl achievement gap across virtually all school quintiles constitutes some evidence in support of the hypothesis that part of the pro-girl advantage in educational outcomes is due to girls exhibiting more of the behaviours that are rewarded in school and support learning. Moreover, the fact that this variable contributes more to the gender gap among students in wealthier schools in PIRLS suggests the return on doing homework - in terms of learning outcomes - is higher in better-resourced schools than in more disadvantaged schools.

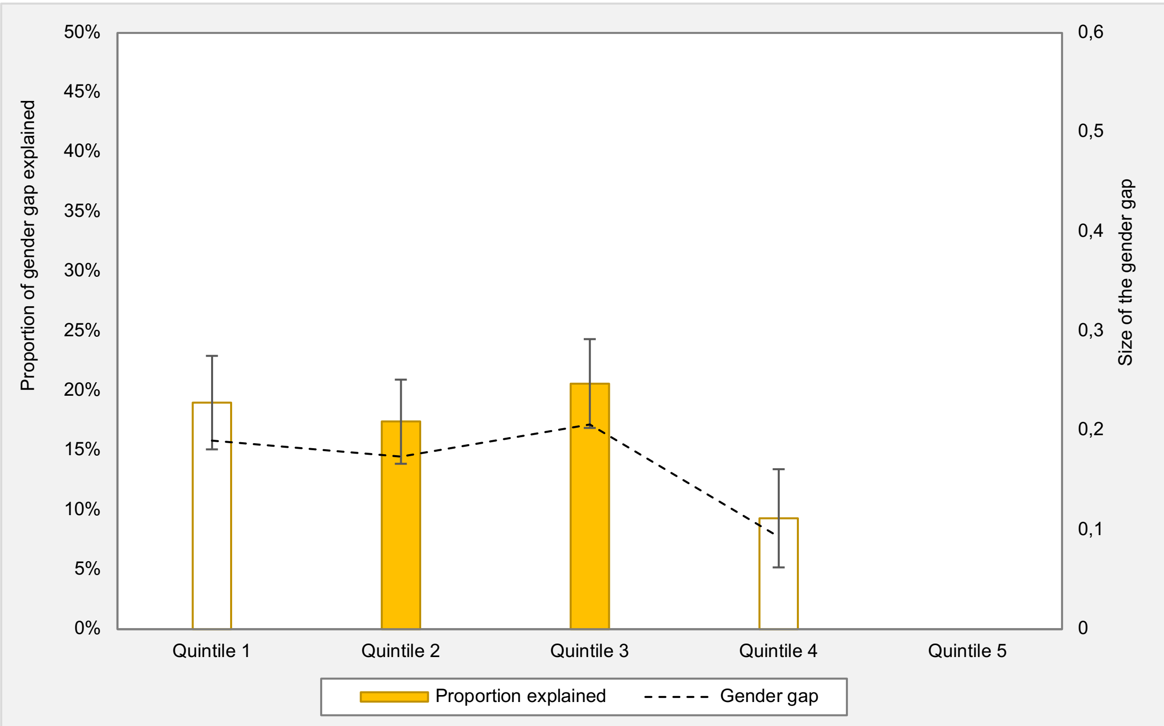
It is interesting to note that the pro-boy advantage in asset index scores observed in Section 3.3 does not hold in a multivariate context: The lack of statistically significant coefficients on the asset index (reported in the "Explained" column) in Table 5 and Table 6 suggests that boys and girls do not differ significantly in terms of their endowments of home assets in either PIRLS or TIMSS. This result constitutes some evidence that boys were more prone to over-reporting on the home possession questionnaire items, that is, that there are not in actual fact significant differences in student wealth by gender.

Figure 10: Magnitude of explained component of the gender gap in PIRLS, by school quintile, for samples that are the correct age-for-grade



Sources: Author's calculations from PIRLS 2016 (Restricted sample of 8,022 students (46% male)). Note: Only student attitudes that significantly contribute to the gender gap in achievement are plotted.

Figure 11: Magnitude of explained component of the gender gap in TIMSS, by school quintile, for samples that are the correct age-for-grade



Source: Author's calculations from TIMSS Numeracy 2015 (Restricted sample of 7,409 students (46% male)). Notes: Unshaded bars indicate that the explained component is not statistically significant. No components plotted for Quintile 5 schools since the gender achievement gap among students in these schools is not statistically significant. No components plotted for student attitudes since these variables do not significantly contribute to the explained component of the gender gap.

Table 5: Results from the second decomposition (only students who are the correct age-for-grade): PIRLS (Grade 4)

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
Gender gap	-0.495***		-0.381***		-0.438***		-0.464***		-0.309***	
	(0.051)		(0.032)		(0.036)		(0.038)		(0.048)	
Boys' average	-0.376***		-0.308***		-0.084		-0.084		0.712***	
	(0.085)		(0.050)		(0.047)		(0.047)		(0.105)	
Girls' average	0.119		0.073***		0.354***		0.354***		1.021***	
	(0.061)		(0.032)		(0.040)		(0.040)		(0.094)	
	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained
Confidence index	-0.045***	-0.026	-0.014***	-0.000	-0.051***	0.001	-0.045***	-0.004	-0.062***	-0.003
	(0.013)	(0.013)	(0.006)	(0.001)	(0.012)	(0.005)	(0.011)	(0.003)	(0.016)	(0.015)
Engagement index	-0.004	-0.004	-0.027***	-0.000	-0.005	-0.002	-0.023***	0.000	-0.017**	-0.003
	(0.004)	(0.005)	(0.006)	(0.001)	(0.007)	(0.003)	(0.007)	(0.005)	(0.008)	(0.013)
Enjoyment index	-0.021	0.002	-0.027**	0.000	-0.036**	-0.013	-0.030***	-0.006	-0.006	0.003
	(0.010)	(0.004)	(0.010)	(0.001)	(0.014)	(0.009)	(0.008)	(0.007)	(0.012)	(0.004)
Belonging index	-0.000	-0.012	-0.013**	-0.001	-0.020	-0.004	-0.010**	0.001	-0.003	-0.000
	(0.002)	(0.013)	(0.005)	(0.004)	(0.013)	(0.005)	(0.004)	(0.003)	(0.003)	(0.001)
Bullying index	-0.014	0.003	-0.016	0.005	-0.011	-0.001	-0.014**	0.001	-0.010	0.005
	(0.009)	(0.010)	(0.007)	(0.003)	(0.005)	(0.008)	(0.005)	(0.002)	(0.006)	(0.009)
Homework	-0.018**	0.015	-0.023***	-0.035	-0.013**	0.012	-0.020***	-0.008	-0.033**	0.022
	(0.008)	(0.018)	(0.005)	(0.026)	(0.005)	(0.024)	(0.006)	(0.017)	(0.013)	(0.044)
Attended ECD	-0.005	-0.017	-0.002	-0.165	0.001	-0.171	-0.001	-0.292***	0.006	-0.036
	(0.003)	(0.124)	(0.001)	(0.105)	(0.002)	(0.126)	(0.001)	(0.093)	(0.003)	(0.149)
Asset index	-0.001	-0.094**	-0.000	-0.026**	-0.005	0.007	0.003	0.001	0.001	-0.055
	(0.005)	(0.038)	(0.001)	(0.012)	(0.004)	(0.004)	(0.002)	(0.010)	(0.002)	(0.028)
First language	0.016**	-0.295***	0.005**	-0.018	-0.001	0.217***	-0.003	-0.014	0.007	-0.000
	(0.007)	(0.056)	(0.002)	(0.072)	(0.001)	(0.064)	(0.002)	(0.060)	(0.005)	(0.054)
African language school	-0.007**	0.077	-0.012**	0.147	0.007	-0.087**	-0.009	0.050	0.020	-0.010
	(0.003)	(0.126)	(0.005)	(0.072)	(0.005)	(0.040)	(0.007)	(0.048)	(0.018)	(0.022)
School has a library	-0.001	-0.002	-0.000	0.001	0.001	-0.031	0.002	0.080**	0.000	0.021
	(0.001)	(0.022)	(0.001)	(0.015)	(0.003)	(0.019)	(0.004)	(0.037)	(0.002)	(0.036)
School has computers	-0.003	-0.031	-0.000	0.022	0.001	0.024	0.000	-0.008	0.000	0.091**
	(0.004)	(0.019))	(0.002)	(0.014)	(0.002)	(0.011)	(0.003)	(0.047)	(0.001)	(0.034)
Constant		-0.006		-0.230		-0.275		-0.166		-0.460***
		(0.160)		(0.140)		(0.181)		(0.085)		(0.153)
Total	-0.096***	-0.400***	-0.115***	-0.266***	-0.140***	-0.299***	-0.150***	-0.314***	-0.095***	-0.214***
	(0.022)	(0.041)	(0.014)	(0.030)	(0.026)	(0.025)	(0.021)	(0.038)	(0.031)	(0.034)
N	1,347		1,514		1,698		1,707		1,756	

Notes: All models include controls for province. Standard errors are calculated at the school level and reported in parentheses. *** p < 0.01; ** p < 0.05; * p < 0.1.

Table 6: Results from the second decomposition (only students who are the correct age-for-grade): TIMSS (Grade 5)

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
Gender gap	-0.190*** (0.050)		-0.174*** (0.041)		-0.206*** (0.026)		-0.093*** (0.031)		0.134 (0.083)	
Boys' average	-0.532*** (0.088)		-0.398*** (0.040)		-0.196*** (0.031)		0.304*** (0.042)		1.180*** (0.070)	
Girls' average	-0.342*** (0.058)		-0.224*** (0.047)		0.010 (0.034)		0.397*** (0.040)		1.046*** (0.097)	
	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained
Confidence index	-0.004 (0.008)	-0.016 (0.012)	-0.004 (0.008)	-0.000 (0.003)	-0.005 (0.006)	0.000 (0.001)	0.014 (0.009)	0.003 (0.004)	0.049*** (0.016)	0.027 (0.014)
Engagement index	0.012 (0.009)	-0.000 (0.006)	0.012 (0.009)	0.023** (0.010)	-0.002 (0.002)	0.004 (0.004)	-0.000 (0.003)	-0.013 (0.009)	0.000 (0.001)	-0.018 (0.010)
Enjoyment index	-0.018 (0.009)	0.006 (0.008)	-0.018 (0.009)	0.002 (0.009)	-0.005 (0.009)	-0.002 (0.002)	0.000 (0.008)	0.015 (0.011)	0.003 (0.008)	-0.006 (0.008)
Belonging index	-0.013 (0.006)	0.003 (0.002)	-0.013 (0.006)	-0.006 (0.005)	-0.003 (0.004)	-0.008 (0.004)	0.000 (0.001)	-0.003 (0.005)	-0.001 (0.005)	0.009 (0.008)
Bullying index	0.001 (0.004)	-0.008 (0.006)	0.001 (0.004)	-0.009 (0.006)	-0.017*** (0.004)	-0.001 (0.001)	-0.019** (0.007)	-0.001 (0.003)	-0.007 (0.006)	-0.029 (0.017)
Homework	0.001 (0.002)	-0.126** (0.046)	0.001 (0.002)	0.075** (0.035)	-0.007** (0.003)	0.032 (0.033)	-0.023*** (0.006)	-0.007 (0.026)	-0.006 (0.004)	0.095 (0.054)
Attended ECD	-0.001 (0.004)	0.032 (0.079)	-0.001 (0.004)	-0.041 (0.053)	-0.001 (0.001)	0.071** (0.028)	-0.000 (0.001)	0.049 (0.042)	0.001 (0.002)	-0.019 (0.043)
Asset index	-0.004 (0.008)	0.048 (0.031)	-0.004 (0.008)	-0.011** (0.004)	0.001 (0.002)	-0.001 (0.002)	-0.003 (0.003)	-0.014 (0.021)	0.001 (0.005)	-0.054 (0.055)
First language	-0.002 (0.004)	0.006 (0.016)	-0.002 (0.004)	-0.036*** (0.011)	-0.002 (0.002)	0.007 (0.011)	-0.014 (0.009)	-0.027 (0.026)	-0.020 (0.018)	-0.049 (0.045)
School has a library	-0.004 (0.005)	0.020 (0.014)	-0.002 (0.003)	0.040** (0.017)	0.003 (0.002)	0.028 (0.015)	-0.001 (0.001)	-0.040 (0.026)	0.020 (0.012)	0.126 (0.187)
School has computers	0.000 (0.001)	0.024 (0.013)	-0.001 (0.004)	-0.009 (0.013)	0.001 (0.003)	-0.013 (0.022)	0.005 (0.004)	-0.059** (0.025)	0.043 (0.028)	-0.034 (0.154)
Constant		-0.150 (0.119)		-0.132 (0.074)		-0.284*** (0.037)		0.046 (0.071)		0.014 (0.183)
Total	-0.033 (0.020)	-0.157*** (0.048)	-0.070*** (0.018)	-0.105** (0.037)	-0.040** (0.019)	-0.166*** (0.019)	-0.041 (0.021)	-0.052** (0.019)	0.072 (0.055)	0.062 (0.060)
N	1,178		1,531		1,527		1,718		1,455	

Notes: All models include controls for province. Standard errors are calculated at the school level and reported in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

6. Discussion

The results presented in this paper make an important contribution to our understanding of the sources of South Africa's pro-girl advantage in reading and mathematics achievement in the primary school grades. By employing a decomposition approach to the country's PIRLS and TIMSS results, I am able to separate gender gaps in reading and mathematics achievement into their explained and unexplained components, which provides some indication of the observable differences between boys and girls, and differences in how those characteristics are translated into achievement, that may contribute to achievement gaps in learning outcomes.

6.1. Summary of main results

Three main results emerge from the analysis presented here. Firstly, in terms of the main research question, the results from the first set of decompositions indicate that around 40% of the pro-girl gap in PIRLS and around 50% of the pro-girl gap in TIMSS can be explained by differences in endowments of observable characteristics between boys and girls captured in these datasets. The magnitudes of these explained components of the gender gap in achievement are similar to those found in studies conducted in other countries that employ a similar methodology (see for example Badr, Morrissey and Appleton (2012); Cobb-Clark and Moschion (2017)). When accounting for gendered repetition patterns in prior grades, however, the size of the explained component of the gender gap decreases significantly in both PIRLS and TIMSS. This effect is particularly pronounced in TIMSS, where the explained component of the gender gap is reduced to insignificance in two of the four quintiles with a significant pro-girl achievement gap in the second set of decompositions. This result constitutes some evidence in support of the hypothesis posited in the introduction, namely that part of the observed pro-girl achievement gaps in these datasets may be due to a selection effect whereby a given Grade 4 or 5 class consists of a larger proportion of boys than girls who have repeated a grade. This, in turn, suggests that the pro-girl achievement gaps observed in PIRLS and TIMSS are partly the result of a pro-girl advantage that is already evident at the start of formal schooling. Importantly, however, the second set of decompositions show that large pro-girl achievement gaps remain in both PIRLS and TIMSS, even when limiting the samples to only students who are on-track in terms of age-for-grade. In other words, while the first set of decompositions show that girls' advantage in terms of prior grade completion does contribute to the observed pro-girl gap in both PIRLS and TIMSS, the results from the second set of decompositions of the performance of on-track students indicate that girls' advantage in the prior grades only *partly* explains the pro-girl gaps in these datasets.

Secondly, the results from the second set of decompositions (for on-track students) suggest that while differences in boys' and girls' attitudes toward reading and school contribute significantly to the observed pro-girl achievement gap in PIRLS, even when considering only students who are on-track in terms of age, this is not the case for TIMSS. This constitutes a noteworthy result since it suggests there is an element of domain specificity to the role of student attitudes in South Africa's pro-girl advantage in educational outcomes, whereby gender differences in the same set of subject-specific attitudes do not contribute equally to girls' advantage in TIMSS mathematics achievement as they do to girls' advantage in PIRLS reading achievement. Specifically, girls' higher reading self-concept as well as their higher enjoyment of reading contribute significantly to the pro-girl gap in PIRLS across virtually all school quintiles. By contrast, even though girls in TIMSS have more positive attitudes toward mathematics than boys, these differences do not significantly contribute to the pro-girl advantage in TIMSS scores. This is in line with existing evidence in the international literature that the nature of gendered educational outcomes differs across domains, especially reading and mathematics (Cobb-Clark and Moschion, 2017).

Lastly, I present evidence that the magnitude of the pro-girl gaps in both PIRLS and TIMSS are related to the SES of the school, with larger gaps observed in the lower school quintiles. This effect is particularly pronounced in TIMSS, where splitting the sample into school SES quintiles reveals that the pro-girl gap observed for the full sample masks the fact that there is no significant pro-girl gap in the wealthiest 20% of schools. Similarly, I find that there are SES differences in the significance of student attitudes in explaining the pro-girl gaps in PIRLS. Together, these results suggest that gender, SES, and student attitudes all interact to produce learning outcomes, something that has received scant attention in the local literature to date. This result suggests that interrogating the intersection between gender, SES and student attitudes further is likely to add more nuance to our understanding of how these factors interact to produce learning outcomes in South Africa more generally.

6.2. Limitations

While these results make an important contribution to our understanding of South Africa's pro-girl advantage in educational outcomes, the analysis presented here is subject to a number of limitations. Firstly, the results presented here are subject to the same limitations that plague all studies that employ Oaxaca-Blinder decomposition analysis (see Fortin, Lemieux and Firpo (2011) for a comprehensive discussion of these issues). Perhaps most pressingly, interpreting the unexplained component of the gender gap as a response effect requires the assumption that all factors that matter for achievement are included in the decomposition model (Jann, 2008). This is of course a very difficult condition to meet, and consequently the nature of the unexplained components of the gender gaps was deliberately de-emphasised in this paper. While the results presented here of the role of endowment differences between boys and girls in explaining South Africa's pro-girl gap in PIRLS and TIMSS constitute an important contribution to the literature, there is still much that we do not know regarding potential differences in how the endowments of boys and girls are translated into achievement. Given evidence in the international literature of such effects, future research in South Africa would do well to investigate this further.

A second major limitation lies in the construct validity of the measures aimed at tapping student attitudes toward school and learning. Importantly, the psychometric properties of these measures have not been established in the South African context, and existing evidence from PIRLS and TIMSS data from other countries suggests these measures may be subject to a number of limitations, including method and translation effects (see for example Marsh *et al.* (2013); Bofah and Hannula (2015); and Alghamdi (2018)). Moreover, there may be important differences in how boys and girls respond to the questionnaire items aimed at identifying these constructs. Despite these limitations, I maintain that these measures do capture something about the more affective aspects of learning that meaningfully contributes to South Africa's pro-girl achievement gap. Another important avenue for future research would be further investigating the role of student attitudes, and non-cognitive skills more generally, in contributing to South Africa's pro-girl gap in education.

Thirdly, the PIRLS and TIMSS assessments are by grade and not by age (such as, for example, the Programme for International Student Assessment (PISA), which tests all 15-year-olds regardless of what grade they are in), thus it does not allow for analysis of all members of the same cohort. Limiting the sample to students who are on-track in terms of age-for-grade allows one to get closer to the 'true' cohort that started school together in Grade 1. However the sample of students remains a pseudo cohort, since it includes students from a previous cohort (students who started school early and repeated a grade), or excludes students from the true cohort (students who started school late and never repeated). This limitation points to the need for international educational assessments to include items in the student background questionnaire that would provide a more detailed picture of students' past educational trajectories, such as asking students whether they have ever repeated a grade.

Lastly, while the results of this paper highlight the importance of gendered repetition patterns in the early grades in contributing to South Africa's observed pro-girl achievement gap in Grade 4 reading and Grade 5 mathematics, this result only shifts the question of the sources of the pro-girl advantage to the early grades. That is, the results presented here do not bring us any closer to understanding *why* boys are underachieving relative to girls in the early grades. To my knowledge, there is only one published study that investigates gender differences in early learning outcomes in South Africa: that of Wilsenach and Makaure (2018), who investigate gender differences in phonological processing skills among Northern Sotho-speaking Grade 3 students, and present evidence of a pro-girl advantage in these skills. The results from the decomposition analysis in this paper suggest much more needs to be done to understand the reasons behind boys' disadvantage in the early grades, since much of the pro-girl achievement gap in Grade 4 reading and Grade 5 mathematics can be attributed the pro-girl advantage in grade completion in the early grades.

7. Conclusion

This paper contributes to the literature documenting South Africa's pro-girl advantage in educational outcomes, and adds to our understanding of the sources of the pro-girl achievement gaps in Grade 4 reading and Grade 5 mathematics by decomposing these gaps into their explained and unexplained components, respectively. The analysis in this paper focussed on three aspects of the pro-girl achievement gap that has hitherto received little attention, namely the potential role of gendered repetition patterns in the foundation phase in contributing to the observed pro-girl gap in PIRLS and TIMSS; differences in the magnitude and potential sources of this gap among students from different socioeconomic backgrounds; and the contribution of gender differences in student attitudes to this gap. The results of the analysis suggest that different processes are at play in the production of South Africa's pro-girl gap in reading and mathematics achievement, and for students from different socioeconomic backgrounds. Although the results presented here constitute an important first step towards understanding the sources of South Africa's pro-female advantage in educational outcomes, we need to do more to understand why this gap is so pronounced and persistent across the education system, with research that focusses on gender gaps in the early grades likely constituting a particularly fruitful avenue for future research.

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Appendix

Table A1: Gender differences in student-reported home possessions, by school quintile (PIRLS 2016, Grade 4)

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5		Total	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Computer	0.19	0.18	0.32	0.30	0.48	0.42***	0.59	0.56*	0.79	0.76	0.49	0.47***
Study desk	0.32	0.39***	0.55	0.58	0.57	0.61	0.62	0.67**	0.72	0.77**	0.55	0.60***
Cell phone	0.40	0.37	0.54	0.46***	0.63	0.57***	0.69	0.64***	0.75	0.72**	0.61	0.56***
Gaming station	0.20	0.14***	0.32	0.24***	0.43	0.25***	0.54	0.35***	0.72	0.45***	0.45	0.29***
Own room	0.42	0.37**	0.57	0.50***	0.60	0.56**	0.65	0.60**	0.75	0.70***	0.60	0.55***
Internet access	0.12	0.08***	0.25	0.18***	0.29	0.22***	0.42	0.35***	0.54	0.48**	0.33	0.27***
Own books	0.40	0.46***	0.55	0.59***	0.58	0.69***	0.65	0.76***	0.72	0.84***	0.58	0.68***
Daily newspaper	0.24	0.27	0.36	0.36	0.45	0.46	0.49	0.48	0.60	0.65**	0.43	0.45**
N	1,037	987	1,171	1,085	1,322	1,238	1,251	1,252	1,228	1,163	6,009	5,725
Proportion	51%	49%	52%	48%	52%	48%	50%	50%	51%	49%	51%	49%

Notes: Asterisks indicate statistically significant differences in the proportions of boys and girls in each quintile who indicated that they had the given item in their home. Significance levels: *p<0.10; **<p<0.05; ***p<0.01.

Table A2: Gender differences in student-reported home possessions, by school quintile (TIMSS 2015, Grade 5)

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5		Total	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Computer	0.33	0.29**	0.42	0.38**	0.42	0.41	0.44	0.43	0.61	0.62	0.49	0.46***
Study desk	0.38	0.37	0.54	0.53	0.52	0.54	0.58	0.63***	0.77	0.78	0.55	0.57
Cell phone	0.47	0.39***	0.54	0.48***	0.63	0.55***	0.68	0.60***	0.76	0.71**	0.61	0.54***
Own room	0.42	0.34***	0.54	0.45***	0.55	0.49***	0.62	0.50***	0.72	0.66***	0.57	0.48***
Internet access	0.22	0.13***	0.28	0.20***	0.32	0.24***	0.41	0.35***	0.66	0.62**	0.37	0.30***
Electricity	0.60	0.61	0.73	0.75	0.81	0.82	0.89	0.91*	0.96	0.96	0.79	0.81
Running water	0.38	0.45***	0.54	0.62***	0.65	0.69**	0.71	0.78***	0.87	0.91**	0.63	0.69***
Fridge	0.74	0.70	0.82	0.81	0.88	0.89	0.93	0.95*	0.97	0.98	0.87	0.86
N	1,063	1,031	1,198	1,125	1,216	1,163	1,225	1,107	899	905	5,601	5,331
Proportion	51%	49%	52%	48%	51%	49%	53%	47%	50%	50%	51%	49%

Notes: Asterisks indicate statistically significant differences in the proportions of boys and girls in each quintile who indicated that they had the given item in their home. Significance levels: *p<0.10; **<p<0.05; ***p<0.01.

Table A3: Responses to student confidence items, by gender and overage (PIRLS)

Questionnaire item	Proportion that answered "Agree a lot"			
	On-track		Overage	
	Boys	Girls	Boys	Girls
I usually do well in reading	0.71***	0.79	0.68*	0.73
Reading is harder for me than for any of my classmates*	0.25	0.30	0.21	0.24
I am just not good at reading*	0.32**	0.39	0.25**	0.31
Reading is easy for me	0.59***	0.69	0.53***	0.63
I have trouble with difficult words*	0.17	0.21	0.14	0.17
Reading is harder for me than any other subject*	0.28**	0.34	0.22	0.24

* Reverse-coded

Table A4: Responses to reading engagement items, by gender and overage (PIRLS)

Questionnaire item	Proportion that answered "Agree a lot"			
	On-track		Overage	
	Boys	Girls	Boys	Girls
I know what my teacher expects me to do	0.62***	0.69	0.58**	0.65
My teacher is easy to understand	0.61***	0.68	0.59*	0.64
I am interested in what my teacher says	0.63***	0.73	0.59**	0.66
My teacher gives me interesting things to read	0.64***	0.74	0.58***	0.68
My teacher lets me show what I have learned	0.61***	0.70	0.58*	0.63
My teacher does a variety of things to help us learn	0.64***	0.74	0.62**	0.68
My teacher tells me how to do better when I make a mistake	0.59***	0.66	0.56**	0.62
My teacher encourages me to say what I think about what I've read	0.60***	0.68	0.58	0.61

Table A5: Responses to reading enjoyment items, by gender and overage (PIRLS)

Questionnaire item	Proportion that answered "Agree a lot"			
	On-track		Overage	
	Boys	Girls	Boys	Girls
I like it when a book helps me to imagine other worlds	0.77	0.79	0.76	0.75
I would be happy if I got a book as a gift	0.23*	0.19	0.32**	0.25
I like reading things that make me think	0.15	0.15	0.25	0.24
I would like to have more time for reading	0.72	0.73	0.66	0.65
I like talking about what I read with other people	0.74*	0.78	0.70	0.70
I think reading is boring*	0.66	0.68	0.64	0.65
I learn a lot from reading	0.65	0.66	0.60	0.61
I like what I read in school	0.65	0.66	0.59	0.60
I enjoy reading	0.69	0.68	0.65	0.64
	Proportion that answered "Every day or almost every day"			
	On-track		Overage	
	Boys	Girls	Boys	Girls
How often do you read for fun?	0.54***	0.63	0.54**	0.60
How often do you read about things you want to learn?	0.62**	0.68	0.60*	0.64

* Reverse-coded

Table A6: Responses to school belonging items, by gender and overage (PIRLS)

Questionnaire item	Proportion that answered "Agree a lot"			
	On-track		Overage	
	Boys	Girls	Boys	Girls
I am proud to go to this school	0.62***	0.72	0.59**	0.66
I feel safe when I am at school	0.63***	0.73	0.59*	0.65
I feel like I belong at this school	0.62*	0.67	0.59*	0.64
Teachers at my school are fair to me	0.54***	0.62	0.52*	0.57
I like being in school	0.75***	0.85	0.72**	0.78

Table A7: Responses to student bullying items, by gender and overage (PIRLS)

Questionnaire item	Proportion that answered "At least once a week"			
	On-track		Overage	
	Boys	Girls	Boys	Girls
How often are you made fun of or called names?	0.34*	0.29	0.36*	0.32
How often have other students left you out of their games or activities?	0.26	0.24	0.37**	0.46
How often have other students spread lies about you?	0.26	0.25	0.27	0.26
How often have other students stolen something from you?	0.27	0.28	0.29	0.29
How often have other students hit you or hurt you?	0.27	0.26	0.28	0.26
How often have other students made you do things you didn't want to do?	0.21	0.19	0.24	0.21
How often have other students shared embarrassing information about you?	0.22	0.22	0.23	0.23
How often have other students threatened you?	0.24	0.24	0.25	0.24

Table A8: Responses to student confidence items, by gender and overage (TIMSS)

Questionnaire item	Proportion that answered "Agree a lot"			
	On-track		Overage	
	Boys	Girls	Boys	Girls
I usually do well in mathematics	0.63*	0.59	0.60**	0.54
Mathematics is harder for me than for any of my classmates*	0.29	0.25	0.34*	0.30
I am just not good at mathematics*	0.29***	0.19	0.29	0.27
I learn things quickly in mathematics	0.62*	0.58	0.53	0.53
Mathematics makes me nervous*	0.30	0.28	0.35	0.33
I am good at working out difficult mathematics problems	0.51	0.48	0.48	0.45
My teacher tells me I am good at mathematics	0.51*	0.47	0.48	0.45
Mathematics is harder for me than any other subject*	0.29*	0.25	0.36*	0.32
Mathematics makes me confused*	0.28	0.25	0.35*	0.31

* Reverse-coded

Table A9: Responses to student engagement items, by gender and overage (TIMSS)

Questionnaire item	Proportion that answered "Agree a lot"			
	On-track		Overage	
	Boys	Girls	Boys	Girls
I know what my teacher expects me to do	0.75	0.76	0.71	0.71
My teacher is easy to understand	0.66	0.69	0.62	0.63
I am interested in what my teacher says	0.70	0.73	0.64*	0.69
My teacher gives me interesting things to do	0.70	0.72	0.65	0.67
My teacher has clear answers to my questions	0.71	0.72	0.66	0.68
My teacher is good at explaining mathematics	0.78	0.80	0.72	0.75
My teacher lets me show what I have learned	0.66	0.69	0.64	0.64
My teacher does a variety of things to help us learn	0.73	0.75	0.66*	0.71
My teacher tells me how to do better when I make a mistake	0.74	0.76	0.67	0.70
My teacher listens to what I have to say	0.70	0.73	0.66	0.69

Table A10: Responses to mathematics enjoyment items, by gender and overage (TIMSS)

Questionnaire item	Proportion that answered "Agree a lot"			
	On-track		Overage	
	Boys	Girls	Boys	Girls
I enjoy learning mathematics	0.77	0.79	0.76	0.75
I wish I did not have to study mathematics*	0.23*	0.19	0.32**	0.25
Mathematics is boring*	0.15	0.15	0.25	0.24
I learn many interesting things in mathematics	0.72	0.73	0.66	0.65
I like mathematics	0.74*	0.78	0.70	0.70
I like any schoolwork that involves numbers	0.66	0.68	0.64	0.65
I like to solve mathematics problems	0.65	0.66	0.60	0.61
I look forward to mathematics lessons	0.65	0.66	0.59	0.60
Mathematics is one of my favourite subjects	0.69	0.68	0.65	0.64

* Reverse-coded

Table A12: Responses to school belonging items, by gender and overage (TIMSS)

Questionnaire item	Proportion that answered "Agree a lot"			
	On-track		Overage	
	Boys	Girls	Boys	Girls
I am proud to go to this school	0.76*	0.80	0.67**	0.74
I feel safe when I am at school	0.73	0.74	0.68*	0.72
I feel like I belong at this school	0.67	0.70	0.62*	0.66
Teachers at my school are fair to me	0.59	0.58	0.53	0.55
I like being in school	0.78*	0.83	0.77*	0.81

Table A13: Responses to student bullying items, by gender and overage (TIMSS)

Questionnaire item	Proportion that answered "At least once a week"			
	On-track		Overage	
	Boys	Girls	Boys	Girls
How often are you made fun of or called names?	0.41***	0.33	0.44**	0.38
How often have other students left you out of their games or activities?	0.29***	0.20	0.30***	0.21
How often have other students spread lies about you?	0.26	0.23	0.28	0.28
How often have other students stolen something from you?	0.32	0.30	0.32	0.30
How often have other students hit you or hurt you?	0.23	0.20	0.25*	0.21
How often have other students made you do things you didn't want to do?	0.21**	0.16	0.26***	0.18
How often have other students shared embarrassing information about you?	0.22	0.19	0.25	0.22
How often have other students threatened you?	0.23*	0.19	0.24	0.21

Table A14: Decomposition results – Full samples

	PIRLS (Reading) Grade 4					TIMMS (Mathematics) Grade 5				
	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Gender gap	-0.433***	-0.406***	-0.514***	-0.528***	-0.423***	-0.203***	-0.228***	-0.172***	-0.173***	-0.057
	(0.045)	(0.037)	(0.036)	(0.048)	(0.046)	(0.037)	(0.036)	(0.037)	(0.029)	(0.085)
Boys' average	-0.481***	-0.387***	-0.281***	-0.321***	0.364***	-0.650***	-0.473***	-0.201***	0.154**	0.925***
	(0.064)	(0.069)	(0.057)	(0.056)	(0.090)	(0.060)	(0.060)	(0.056)	(0.060)	(0.113)
Girls' average	-0.048	0.019	0.233***	0.206***	0.787***	-0.447***	-0.245***	-0.029	0.327***	0.982***
	(0.051)	(0.053)	(0.056)	(0.053)	(0.079)	(0.053)	(0.055)	(0.046)	(0.057)	(0.104)
	Explained	Explained	Explained	Explained	Explained	Explained	Explained	Explained	Explained	Explained
Overage	-0.031***	-0.045***	-0.041***	-0.044***	-0.033***	-0.030***	-0.052***	-0.032***	-0.048***	-0.048***
	(0.008)	(0.010)	(0.009)	(0.009)	(0.009)	(0.008)	(0.009)	(0.007)	(0.010)	(0.016)
Confidence index	-0.048***	-0.021***	-0.043***	-0.038***	-0.076***	-0.008	-0.015***	-0.009	-0.000	0.014
	(0.012)	(0.008)	(0.010)	(0.010)	(0.016)	(0.006)	(0.005)	(0.007)	(0.006)	(0.015)
Engagement index	-0.014***	-0.029***	-0.013**	-0.021***	-0.019***	-0.004	-0.012***	-0.005	-0.003	-0.001
	(0.006)	(0.008)	(0.005)	(0.006)	(0.006)	(0.003)	(0.005)	(0.003)	(0.002)	(0.001)
Enjoyment index	-0.021***	-0.025***	-0.048***	-0.031***	0.012	-0.021***	-0.037***	-0.013	-0.011	0.001
	(0.007)	(0.008)	(0.011)	(0.008)	(0.010)	(0.007)	(0.010)	(0.007)	(0.006)	(0.004)
Belonging index	-0.005	-0.013***	-0.018***	-0.015***	0.009	-0.014**	-0.007	-0.007	-0.003	-0.001
	(0.004)	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)	(0.005)	(0.004)	(0.003)	(0.004)
Bullying index	-0.003	-0.009	-0.015***	-0.010***	-0.016***	-0.010	-0.022***	-0.014***	-0.017***	-0.014***
	(0.003)	(0.004)	(0.005)	(0.004)	(0.005)	(0.006)	(0.007)	(0.005)	(0.006)	(0.006)
Homework	-0.015***	-0.024***	-0.013***	-0.015***	-0.056***	-0.001	-0.003	-0.002	-0.014***	-0.013***
	(0.005)	(0.007)	(0.005)	(0.005)	(0.014)	(0.001)	(0.002)	(0.002)	(0.005)	(0.006)
Attended ECD	-0.000	-0.000	-0.000	0.001	0.005**	-0.003	-0.001	-0.001	-0.002	0.001
	(0.001)	(0.002)	(0.000)	(0.001)	(0.003)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Asset index	0.003	0.003	-0.003	0.005	0.012**	0.010	0.002	0.002	-0.002	0.000
	(0.002)	(0.002)	(0.003)	(0.003)	(0.005)	(0.005)	(0.003)	(0.002)	(0.003)	(0.005)
First language	0.004	0.001	0.000	-0.007	-0.007	-0.006	0.000	-0.000	-0.003	-0.031
	(0.004)	(0.002)	(0.002)	(0.005)	(0.005)	(0.004)	(0.002)	(0.001)	(0.005)	(0.021)
Constant	-0.129***	-0.161***	-0.203***	-0.176***	-0.170***	0.130	0.090	-0.177	-0.402	-0.622
	(0.022)	(0.020)	(0.023)	(0.024)	(0.030)	(0.182)	(0.245)	(0.191)	(0.312)	(0.424)
Total	-0.129***	-0.161***	-0.203***	-0.176***	-0.170***	-0.084***	-0.148***	-0.080***	-0.107***	-0.116
	(0.022)	(0.020)	(0.023)	(0.024)	(0.030)	(0.022)	(0.021)	(0.020)	(0.019)	(0.069)
N	2,592	2,576	2,563	2,525	2,554	2,094	2,323	2,379	2,332	1,804

Notes: All models include controls for the language of the test, whether the school has a library and computers, and province. Standard errors are calculated at the school level and reported in parentheses.
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

Table A15: Results from the first decomposition (includes overage students): PIRLS Grade 4 (Reading)

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
Gender gap	-0.503***		-0.385***		-0.493***		-0.556***		-0.397***	
	(0.051)		(0.027)		(0.031)		(0.029)		(0.041)	
Boys' average	-0.457***		-0.415***		-0.234***		-0.274***		0.586***	
	(0.062)		(0.045)		(0.047)		(0.050)		(0.100)	
Girls' average	0.046		-0.030		0.259***		0.282***		0.984***	
	(0.054)		(0.029)		(0.034)		(0.043)		(0.089)	
	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained
Overage	-0.036***	0.038	-0.040***	0.035	-0.047***	0.016	-0.038***	-0.040	-0.031***	-0.029**
	(0.010)	(0.019)	(0.008)	(0.022)	(0.009)	(0.019)	(0.006)	(0.022)	(0.008)	(0.011)
Confidence index	-0.045***	-0.017	-0.017***	0.004	-0.046***	-0.002	-0.043***	-0.003	-0.068***	-0.015
	(0.009)	(0.009)	(0.006)	(0.003)	(0.009)	(0.003)	(0.009)	(0.002)	(0.014)	(0.010)
Engagement index	-0.006	-0.002	-0.028***	-0.002	-0.007	-0.000	-0.019***	-0.001	-0.012***	-0.000
	(0.005)	(0.002)	(0.005)	(0.002)	(0.007)	(0.002)	(0.007)	(0.003)	(0.006)	(0.009)
Enjoyment index	-0.022**	0.001	-0.036**	0.001	-0.049**	-0.007	-0.036**	0.001	-0.014	0.002
	(0.009)	(0.003)	(0.007)	(0.000)	(0.012)	(0.007)	(0.006)	(0.004)	(0.009)	(0.003)
Belonging index	0.000	-0.010	-0.014**	-0.001	-0.017	-0.000	-0.006	0.002	-0.004	0.000
	(0.002)	(0.010)	(0.005)	(0.003)	(0.012)	(0.002)	(0.003)	(0.002)	(0.003)	(0.000)
Bullying index	-0.010	-0.004	-0.017***	0.000	-0.013***	-0.003	-0.016***	-0.001	-0.012**	0.003
	(0.006)	(0.010)	(0.005)	(0.001)	(0.003)	(0.004)	(0.005)	(0.001)	(0.005)	(0.006)
Homework	-0.019**	0.009	-0.020***	-0.031	-0.017**	0.008	-0.018***	-0.005	-0.029**	0.040
	(0.007)	(0.017)	(0.004)	(0.016)	(0.006)	(0.024)	(0.005)	(0.014)	(0.012)	(0.035)
Attended ECD	-0.003	0.143	-0.002	-0.060	0.000	0.025	-0.000	-0.061	0.004**	0.095
	(0.002)	(0.106)	(0.002)	(0.076)	(0.002)	(0.119)	(0.000)	(0.077)	(0.002)	(0.108)
Asset index	0.001	-0.056	0.000	-0.006	-0.003	0.001	0.007**	-0.001	0.003	-0.007
	(0.005)	(0.028)	(0.001)	(0.009)	(0.003)	(0.002)	(0.003)	(0.009)	(0.002)	(0.023)
First language	0.007	-0.228***	0.005***	-0.052	-0.000	0.144**	-0.009**	-0.046	0.005	-0.036
	(0.004)	(0.056)	(0.002)	(0.045)	(0.001)	(0.061)	(0.004)	(0.051)	(0.003)	(0.039)
African language school	-0.005	0.025	-0.013**	0.093	0.002	-0.004	-0.021***	0.083	-0.008	0.026
	(0.003)	(0.120)	(0.005)	(0.048)	(0.003)	(0.038)	(0.007)	(0.053)	(0.019)	(0.017)
School has a library	-0.001	0.015	-0.000	0.001	0.001	-0.021	0.002	0.048	0.000	0.064
	(0.001)	(0.025)	(0.001)	(0.010)	(0.003)	(0.024)	(0.004)	(0.030)	(0.002)	(0.036)
School has computers	0.003	-0.037	-0.001	-0.016	-0.001	0.002	0.000	0.028	0.004	0.063
	(0.004)	(0.024)	(0.002)	(0.012)	(0.002)	(0.013)	(0.001)	(0.033)	(0.005)	(0.031)
Constant		-0.283		-0.247		-0.492***		-0.359***		-0.579***
		(0.158)		(0.114)		(0.155)		(0.107)		(0.118)
Total	-0.135***	-0.368***	-0.161***	-0.224***	-0.196***	-0.296***	-0.200***	-0.356***	-0.168***	-0.230***
	(0.025)	(0.043)	(0.014)	(0.029)	(0.022)	(0.027)	(0.022)	(0.032)	(0.031)	(0.031)
N	2,024		2,256		2,560		2,503		2,391	

Notes: All models control for province. Standard errors are calculated at the school level and reported in parentheses. *** p < 0.01; ** p < 0.05; * p < 0.1.

Table A16: Results from the first decomposition (includes overage students): TIMSS Grade 5 (Mathematics)

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
Gender gap	-0.220***		-0.215***		-0.211***		-0.149***		-0.002	
	(0.058)		(0.030)		(0.024)		(0.027)		(0.071)	
Boys' average	-0.618***		-0.520***		-0.288***		0.168***		0.968***	
	(0.079)		(0.040)		(0.028)		(0.042)		(0.080)	
Girls' average	-0.398***		-0.306***		-0.077***		0.282***		0.970***	
	(0.053)		(0.042)		(0.030)		(0.043)		(0.098)	
	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained
Overage	-0.014	-0.033	-0.052***	0.011	-0.030***	0.023	-0.038***	-0.009	-0.052***	0.020
	(0.008)	(0.030)	(0.007)	(0.017)	(0.005)	(0.016)	(0.006)	(0.013)	(0.014)	(0.017)
Confidence index	-0.006	-0.019	-0.009	0.005	-0.006	0.000	-0.043***	0.000	0.023	0.017
	(0.007)	(0.013)	(0.005)	(0.005)	(0.004)	(0.002)	(0.009)	(0.002)	(0.013)	(0.012)
Engagement index	0.002	-0.009	-0.007***	0.017**	-0.004	0.002	-0.019***	-0.006	-0.000	-0.038***
	(0.006)	(0.009)	(0.002)	(0.008)	(0.002)	(0.002)	(0.007)	(0.006)	(0.000)	(0.011)
Enjoyment index	-0.014	0.024	-0.022**	0.001	-0.010	0.000	-0.036**	0.010	0.003	-0.001
	(0.009)	(0.012)	(0.008)	(0.009)	(0.006)	(0.001)	(0.006)	(0.006)	(0.006)	(0.009)
Belonging index	-0.009	0.001	-0.002	-0.004	-0.006**	-0.002	-0.006	-0.004	-0.003	0.015
	(0.005)	(0.002)	(0.003)	(0.004)	(0.003)	(0.002)	(0.003)	(0.004)	(0.004)	(0.008)
Bullying index	-0.005	-0.008	-0.021***	-0.011	-0.014***	-0.003	-0.016***	-0.003	-0.015**	-0.013
	(0.005)	(0.006)	(0.006)	(0.005)	(0.004)	(0.002)	(0.005)	(0.003)	(0.006)	(0.014)
Homework	-0.002	-0.118**	-0.004	0.030	-0.009**	0.012	-0.018***	0.041	-0.012**	0.089
	(0.003)	(0.042)	(0.003)	(0.028)	(0.004)	(0.029)	(0.005)	(0.038)	(0.006)	(0.058)
Attended ECD	-0.002	0.015	-0.004**	-0.046	-0.007***	0.065**	-0.000	0.025	-0.014***	-0.016
	(0.003)	(0.025)	(0.002)	(0.040)	(0.002)	(0.025)	(0.000)	(0.035)	(0.004)	(0.040)
Asset index	-0.011	0.015	0.000	-0.010***	-0.000	-0.000	0.007**	-0.012	0.001	-0.051
	(0.007)	(0.025)	(0.001)	(0.003)	(0.001)	(0.001)	(0.003)	(0.018)	(0.002)	(0.042)
First language	-0.005	0.022	-0.004	-0.036***	-0.000	0.009	-0.009**	-0.017	-0.034**	-0.071
	(0.004)	(0.018)	(0.003)	(0.010)	(0.002)	(0.018)	(0.004)	(0.026)	(0.015)	(0.038)
School has a library	0.003	0.007	-0.000	0.020	-0.030***	0.038**	0.002	-0.006	-0.052***	0.067
	(0.003)	(0.013)	(0.001)	(0.013)	(0.005)	(0.018)	(0.004)	(0.021)	(0.014)	(0.116)
School has computers	0.001	0.029	-0.001	-0.024	-0.006	0.009	0.000	-0.052**	0.023	0.025
	(0.003)	(0.015)	(0.002)	(0.011)	(0.004)	(0.022)	(0.001)	(0.020)	(0.013)	(0.092)
Constant		-0.016		-0.042		-0.305***		-0.033		0.027
		(0.109)		(0.069)		(0.033)		(0.058)		(0.167)
Total	-0.044**	-0.172**	-0.120***	-0.088***	-0.072***	-0.151***	-0.089***	-0.066***	-0.087	0.077
	(0.018)	(0.065)	(0.020)	(0.025)	(0.014)	(0.027)	(0.022)	(0.014)	(0.053)	(0.054)
N	1,802		2,084		2,207		2,280		1,774	

Notes: All models control for province. Standard errors are calculated at the school level and reported in parentheses. *** p < 0.01; ** p < 0.05; * p < 0.1.