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Timothy Köhler

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Keywords: South Africa, class size, learner outcomes, education, human capital, school quality
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Socioeconomic Status and Class Size in South African Secondary Schools:

Evidence from the 2017/18 School Monitoring Survey and external administrative data

Timothy Köhler[1]

January 2020

Abstract

The reduction of class size is frequently argued to be a relatively simple, cost-effective way to improve learner outcomes in a wide array of contexts. However, methodological concerns regarding the appropriate use of observational data and endogeneity have led to a lack of consensus on this relationship in the literature. In the South African context, most studies which use observational data conclude that on average, greater class sizes are associated with poorer educational outcomes. However, given the country's well-documented bimodal education system, it is plausible to believe that such a relationship may depend on where learners finds themselves in the system. Specifically, given that class size is highly correlated with other measures of school quality, one may not find a significant relationship once such characteristics are accounted for. In this light, this paper merges newly available, school-level data from the 2017/18 School Monitoring Survey with external administrative data to investigate whether the relationship between secondary school class size and learner outcomes varies by school socioeconomic status. Using several learner outcome measures, the findings suggest that although extreme class sizes are concentrated in poorer schools, class size is only negatively associated with learner outcomes in wealthier schools. This does not imply that class size does not matter. Rather, variation in class size appears to be merely indicative of other important factors in poorer quality schools which influence learner outcomes. This suggests that a class size reduction policy may only be effective once other factors relating to school quality are addressed.

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Contents

1 Introduction

The reduction of class sizes is often argued to be one of the most simple and effective ways to improve learner outcomes. However, there is a lack of consensus in the literature on the causal effect of such reductions - a debate rooted in methodological concern. Many argue that the education production function approach - the most popular of estimation strategies in this literature - on non-experimental data yields biased estimates. This is due to the fact that learners, parents, and teachers typically are not randomly assigned to schools and classrooms. In response to this critique, experimental and quasi-experimental studies have sought to yield more reliable estimates of the effect of class size. Despite most of these studies finding positive effects from class size reduction, many assert that any evidence of such effects is merely indicative of other characteristics certain schools exhibit. Only observational studies in this regard exist in the South African context, a country whose public schools - particularly those of a lower socioeconomic status (SES) - are characterised by considerably large class sizes. The South African education system's bimodal distribution of learner outcomes is well-documented, and many studies stress the importance of factors other than class size in improving learning. Using a unique dataset which combines Grade 12 examination data and new data from the 2017/18 School Monitoring Survey never-before used, this paper empirically investigates the relationship between class size and learner outcomes at the school-level in South African public secondary schools. In particular, it focuses on whether this relationship depends on a school's SES, given that there may be implications for conventional school inputs and class size reduction policies if such heterogeneity exists.

2 Literature review

2.1 The class size debate: do reductions in class size matter?

One way to improve learner outcomes that is often thought to be effective is by reducing class sizes in schools (Altinok and Kingdon, 2012:203). From a public choice perspective, it is argued that class size is an easier tool to manipulate relative to other school-related inputs (Angrist and Lavy, 1999:533). Indeed, self-reports from parents and teachers in survey data are indicative of wide-spread preference for smaller classes (Pedder, 2006:219; Angrist and Lavy, 1999:533). Proponents of smaller classes argue that they allow for higher-quality learning opportunities, development of teacher-learner relationships, more individualised and learner-centric instruction, increased teacher morale, and less learner misbehaviour (Chingos, 2013:413; Hattie, 2005:387). Although significant, positive estimates for class size reduction have been found in some studies, several studies assert that it is not smaller class sizes which positively affect learner outcomes but rather other factors which schools with small class sizes tend to exhibit. Because of this discrepancy in the literature, Pedder (2006:214) states that policymakers are rightly informed that evidence of the causal effect of class size is mixed at best.

This lack of consensus is mainly rooted in valid methodological concerns. The use of education production functions on observational data serves as the most common approach to estimating the relationship between class size and learner outcomes (Woesmann and West, 2006:697). However, in reality the assignment of learners and teachers to classrooms and schools is typically non-random. These include unobserved parental preferences to send their children to schools of certain types (Case and Deaton, 1999:1047) in certain neighbourhoods (Rivkin *et al.*, 2005:418), or ensure that their children are taught in a particular class (for example, with their peers or taught by a preferred teacher) (Li and Konstantopoulos, 2016:510). Schools may also use learners' previous academic performance or another form of assessment to assign them to a specific class (Rivkin *et al.*, 2005:418). This means that in such a model, class size will likely be correlated with some unobserved learner, parent, or teacher characteristic(s). The key implication of such selection is that such estimates on non-experimental data will likely be biased.

Given the above endogeneity concern, several studies have used experimental and quasi-experimental methods to reliably estimate the causal effect of class size on learner outcomes. Most findings of these studies suggest that smaller class sizes do indeed have a significant, positive effect on learner outcomes (Krueger, 2003:F34; Juan and Visser, 2017:2). However, the magnitudes of the estimates are often small and inconsistent (Chingos, 2013:412). Several studies have also shown that the effects tend to be larger for learners in lower grades and those regarded as previously disadvantaged (Rivkin *et al.*, 2005:449; Li and Konstantopoulos, 2016:503). Hattie (2005) also stresses that effects vary depending on the size of the reduction. For typical developing country contexts, this latter point is important given the mean class sizes tend to be considerably larger than that of developed countries. Despite the now substantial amount of experimental and quasi-experimental evidence yielding positive class size reduction effects, many remain unconvinced, mainly citing the influential literature of Hanushek (1986, 1989, 1996, 1997, 1998) who asserted that there is no strong or consistent relationship between school-related inputs such as class size and learner outcomes. However, in a reanalysis of some of Hanushek's early meta-analyses, Krueger (2003) concluded that the author inappropriately placed a disproportionate weight on several studies that "frequently used small samples and estimated misspecified models" (pg. F35).

Perhaps two of the most cited studies on class size are those of Krueger (1999) and Angrist and Lavy (1999). The latter study used a quasi-experimental technique (a regression discontinuity design) on observational data to exploit a maximum class size policy rule in the Israeli school system. Their results highlighted a significant, positive effect of a class size reduction on Grade 4 and 5 (but not 3) learner test scores. In the former experimental study - Project STAR (Student/Teacher Achievement Ratio) - learners in Tennessee were randomly assigned into classrooms of various sizes from kindergarten through to Grade 3 in the mid-1980s. Although the gains were small, the results strongly supported class size reductions to improve learner outcomes. Furthermore, there were long-term gains: learners who were in smaller classes were more likely to graduate and get a degree in the STEM field.[2] Although viewed as one of the most impressive studies of its kind (Li and Konstantopoulos, 2016:506), there are concerns pertaining to parental knowledge of the experiment and their consequent choice to participate prior to the start of the experiment (Woesmann and West, 2006:698).

2.2 Class sizes in the South African context

Despite the large amount of research on class size effects in the world, the vast majority has been conducted in and for developed country contexts. The findings of these studies may not be generalisable to developing countries given that, as mentioned previously, the typical class size in the latter is on average considerably larger. Spaull (2016:2) asserts that it is reasonable to hypothesise that class size reduction effects from a higher level (for example, 60 to 40 learners) may differ from those at a lower level. In South African public schools, it is well-documented that class sizes are very high, even by developing country standards (Gustafsson and Mabogoane, 2012:356) and especially in schools that historically catered for Black African learners (Howie, 2005:124). To the author's knowledge, no experimental or quasi-experimental study exists which seeks to estimate the causal effect of class sizes on learner outcomes in SA's context. Despite the lack of causal evidence, legislation on maximum class sizes does exist, although it is suggestive rather than coercive in nature. The post-provisioning norms of 2016 (Government Gazette No. 3968) states that the ideal maximum class size for South African public secondary schools is 37 for Grade 8 and 9. For Grades 10 to 12, the recommended maximum varies by subject but is 35 and 37 for official languages and mathematics.

[2] Science, technology, Engineering, and Mathematics.

There are however several studies which use the popular education production function approach on observational data. The earliest of these (Case and Deaton, 1999) uses administrative data in combination with the 1993 Project for Statistics on Living Standards and Development (PSLSD) survey data to investigate the relationship between several educational inputs and Black African learner outcomes. Although class size was not explicitly examined, the authors argue that class size variation for these learners was mostly exogenous owing to apartheid-era policies' effects on the population's freedom of residential and school choice. The authors found strong effects of pupil-teacher ratios, similar to other findings. Using the Trends in International Mathematics and Science Study (TIMSS) of 1999, Howie (2005) found that 47% of the variation of South African learners' mathematics test scores is explained by just six classroom-level variables, one of which is class size (significant and negatively related). Using TIMSS 2011, Visser *et al.* (2015) also found a negative relationship. Juan and Visser (2017) used the same data and draw similar conclusions for science test scores. Taylor and Yu (2006) found similar results for literacy test scores using the Progress in International Reading and Literacy Study (PIRLS) 2006 data. However, it should be noted that one ought to be cautious in interpreting some of the coefficients in these studies. This is because of the high degree of multi-collinearity between class size and other factors, which may mean that if such factors are not controlled for, class size could act as a sort of proxy for socioeconomic status. For instance, by using the Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ) III data, Spaull (2013) found no significant relationship between class size and literacy or numeracy test scores once such factors were controlled for (irrespective of whether the learners were in the so-called functional or dysfunctional parts of SA's education system).

3 Data and methodology

3.1 The 2017/18 School Monitoring Survey

This paper utilises data from two sources, the first being the 2017/18 School Monitoring Survey (SMS). Conducted in 2017, the SMS is a national, cross-sectional survey of primary- and secondary-school teachers, learners, and principals in public ordinary schools.[3] To the author's knowledge, this is the first knowledgeable study to use the 2017/18 SMS data to analyse the relationship of interest. Commissioned by the national Department of Basic Education (DBE), the goal of the survey was to collect information not available in other datasets and to investigate the progress of schools towards achieving the key goals and indicators of

[3] Special Needs Education Schools, Specialisation Schools, and private schools are excluded.

the DBE's Action Plan 2019 and of the Medium-Term Strategic Framework 2014-2019.[4] The survey consists of a total of five questionnaires administered to principals, Grade 3, 6, 9 and 12 teachers, and appropriate members of school staff knowledgable of learner teaching support material (LTSM) and learners with special educational needs (LSEN). Regarding teachers, at least one Language teacher and one Mathematics teacher in Grades 3, 6, 9, and 12 were interviewed for each school. Stratified by province and school quintile, random samples of 1 000 primary and 1 000 secondary public ordinary schools were planned, resulting in a final 1 976 schools consisting of 8 626 observations being successfully sampled.[5] Unless indicated otherwise, school- and learner-level sample weights were used throughout this analysis to ensure representativeness and adjust for stratum size.[6]

Although the SMS includes several questions administered to learners within the sampled schools, such as the amount of learners who have workbooks and textbooks, the survey does not include any data on a given learner, class, or school's performance in terms of test scores. In this light, a unique dataset is constructed for this paper by merging external, school-level administrative data with the SMS data, as discussed in the next section.

3.2 South Africa's National Senior Certificate

Commonly referred to as the matriculation exam, the National Senior Certificate (NSC) serves as SA's set of secondary school-leaving exams administered by the DBE in all public schools at the end of Grade 12. The NSC data used in this paper is on the school-level and contains each school's (i) Education Management Information System (EMIS) number which serve to identify every school in South Africa by a unique, eight-digit number, and (ii) various performance measures, such as the mean Grade 12 mathematics mark and the proportion of learners who have obtained an NSC pass. The former point is important, given that the EMIS number for every school is included in the SMS data. For the purposes of this analysis, NSC data for the year 2017 was merged to the SMS data using school EMIS numbers. Considering the NSC examination takes place at the end of secondary school, the SMS sample was restricted to include only those observations in secondary schools (i.e. Grade 9 or 12). Most of the sample (97% of observations (4 759 of 4 866) or 97% of schools (964 of 911)) could be matched in this regard.

[4]In particular, the survey focused on 13 of the 15 Action Plan indicators which were measured in the 2011 School Monitoring Survey.

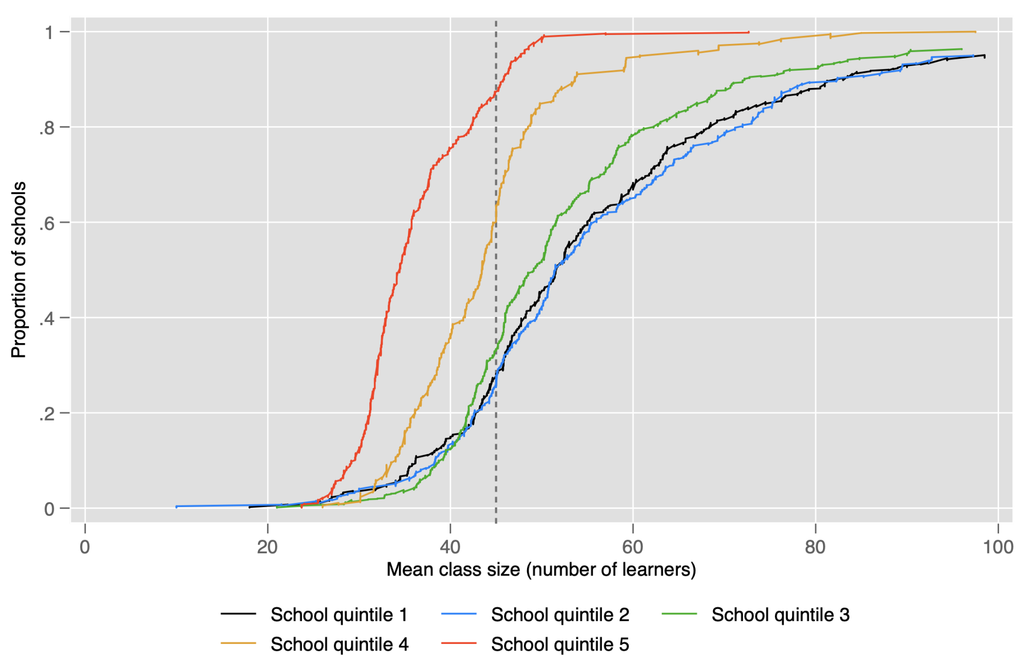
[5]The interested reader is referred to the 2017/18 SMS report for more information on the survey's sampling design, available here: `https://www.education.gov.za/Resources/Reports.aspx`.

[6]The latter weights are used for teachers as observations, as suggested in the 2017/18 SMS report.

3.3 Descriptive statistics

Several policy-relevant studies point to class size as an important determinant of learner outcomes in SA. In the 2016 *Identifying Binding Constraints in Education* report, ensuring no Foundation Phase class is in excess of 45 learners serves as one of six core components of a proposed national reading strategy (Van der Berg *et al.*, 2016:55). Despite the focus of that report on the Foundation Phase, such a component is arguably also suitable for higher phases. The SMS data, which has official school quintiles provided by the DBE,[7] reveals that several secondary schools in every school SES quintile have a mean class size in excess of 45 learners; however, the highest concentration of these classes exist in poorer schools. As shown in Figure 1 which presents the cumulative distributions of the mean class sizes of schools by school quintile, nearly three in every four (73%) classes in Quintile 1 and 2 schools have more than 45 learners, in contrast to 35% and 17% of Quintile 4 and 5 schools respectively. Analysing how learner outcomes vary with such inequalities in class size serves as the beginning of this paper's analysis.

Figure 1: Cumulative density functions of the mean class size of sampled schools by school quintile. Source: 2017/18 SMS.

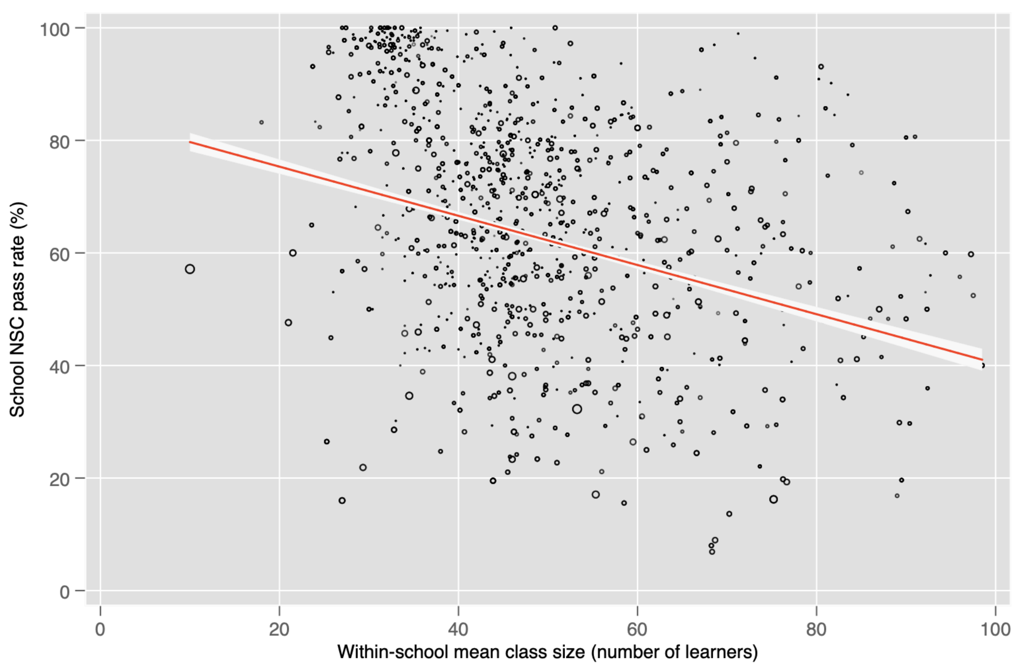


In the SMS, only one class size variable is available for secondary schools - a variable

[7] In the South African education system, public schools are categorised into five quintiles based on the relative socioeconomic status of their surrounding communities.

self-reported by teachers. Teachers were asked "*What is the largest class that you have taught this year?*" in terms of the number of learners. Unless indicated otherwise, "class size" pertains to this variable throughout this paper's analysis. The analysis begins with a simple presentation of the unconditional correlation between class size and learner outcomes. Figure 2 presents the plot, for each given school, of the percentage of learners who obtained an NSC pass and the mean class size.[8] Despite substantial variation around the fitted line, a strong negative correlation is evident: on average, schools which have a larger mean class size have a lower proportion of learners who obtain an NSC pass. Although this proxy for class size may be an inaccurate reflection of actual class sizes, it is arguably a good approximation given data limitations. Furthermore, this relationship holds when using alternative measures of school performance, such as the Bachelor's pass rate (formerly referred to as the matric exemption, a performance level usually providing access to university studies) or the mean Grade 12 mathematics examination mark, as presented in Figures A1 and A2 in the appendix.

Figure 2: Linear plot of the NSC pass rate and mean class size of sampled schools. Source: 2017/18 SMS and external NSC data.

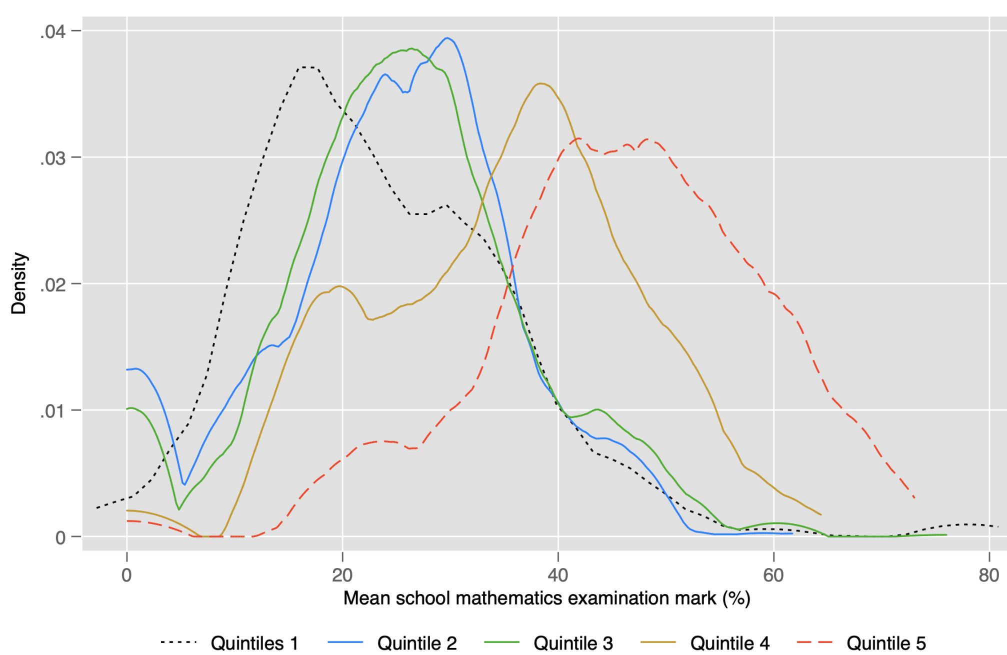


It is widely-documented that the South African education system can be regarded as

[8]Only schools with a maximum of 100 reported learners is included, although the relationship holds without this restriction.

dualistic in nature, consisting of a minority (about 25%) of learners attending mostly functional schools, leaving the majority of learners in dysfunctional schools (Spaull, 2013:437). These are considered as functional and dysfunctional in the sense that the former effectively translates education inputs into adequate learner outcomes. This familiar bimodal distribution of learner outcomes is highlighted in Figure 3, which presents distributions of mean Grade 12 mathematics examination marks for schools sampled in the SMS by school quintile. Examination marks for mathematics in particular are used because it is well-documented that proficiency in the subject is a good predictor of performance in other subjects (Norris, 2012). Visually, the distributions for Quintile 1 to 3 schools are not substantially different, and the mean school mathematics marks between each of these quintiles are not statistically different from one another. In contrast, the location of the distributions for Quintile 4 and 5 schools are notably distanced from those of the bottom 60%. The mean mark in the average Quintile 5 school is more than 20 percentage points higher than that of the average Quintile 1 to 3 school. Such inequality in learner outcomes highlights that this bimodality is hidden when mere averages of learner performance are analysed, as opposed to analysing outcomes between quintiles.

Figure 3: Distribution of mean school Grade 12 mathematics examination marks by school quintile. Author's own calculations. Source: 2017/18 SMS and external NSC data.



Given this paper's focus on variation by school SES, it is worth investigating how this relationship between class size and school performance may differ for schools of different quintile categories. Figure 4 presents the mean NSC pass rates, class sizes, and pupil-teacher ratios (PTRs) by school quintile. PTRs were calculated based on the self-reported answers of two questions from each school's principal: "*How many learners were enrolled in your school?*" and "*How many teachers were employed at your school?*" as of the end of September 2017.[9] It is clear that wealthier schools on average have smaller class sizes and higher NSC pass rates. As previously expressed, Quintile 1 to 3 schools do not differ significantly from one another in these aspects, while there are 20 more learners in the average class in the poorest 60% of schools relative to the wealthiest 20%.[10] This coincides with a more than 30 percentage point difference in inter-quintile NSC pass rates: just 56% of learners in Quintile 1 to 3 schools pass Grade 12 with an NSC, in contrast to 87% of learners in Quintile 5 schools. Including PTR in the figure allows one to assess whether it implies the same thing as class size - the only difference between the two variables relating to how teachers are used. In contrast to class size, it is clear that mean PTRs are relatively constant across the school SES distribution ranging from about 26-28 in Quintile 1 to 4 schools to 24 in Quintile 5 schools respectively - all of which are not statistically significantly different from one another. Expectedly, Figure 5 shows that the lower PTR in the average Quintile 5 school is driven by a greater number of teachers (nearly 20 more) relative to the average Quintile 1 school. Despite such similar mean PTRs, striking realities exist for several poor schools. For instance, there are two Quintile 2 secondary schools in the Eastern Cape which have about 1 050 learners but just 22 teachers.

[9] The definition of teachers here includes both School Governing Body and state-employed teachers, principals, and School Management Team members, teachers, or practitioners (including Grade R teachers). It does not include administrative staff, cleaners, caretakers, security, or student teachers on practical.

[10] Specifically, the mean class sizes of Quintile 1, 2, and 3 schools are 56.34, 57.15, and 54.56 - all of which are not statistically significantly different from one another. The mean class size of Quintile 5 schools is 37.

Figure 4: Mean NSC pass rate, class size, and pupil-teacher ratio by school quintile. Author's own calculations. Source: 2017/18 SMS and external NSC data.

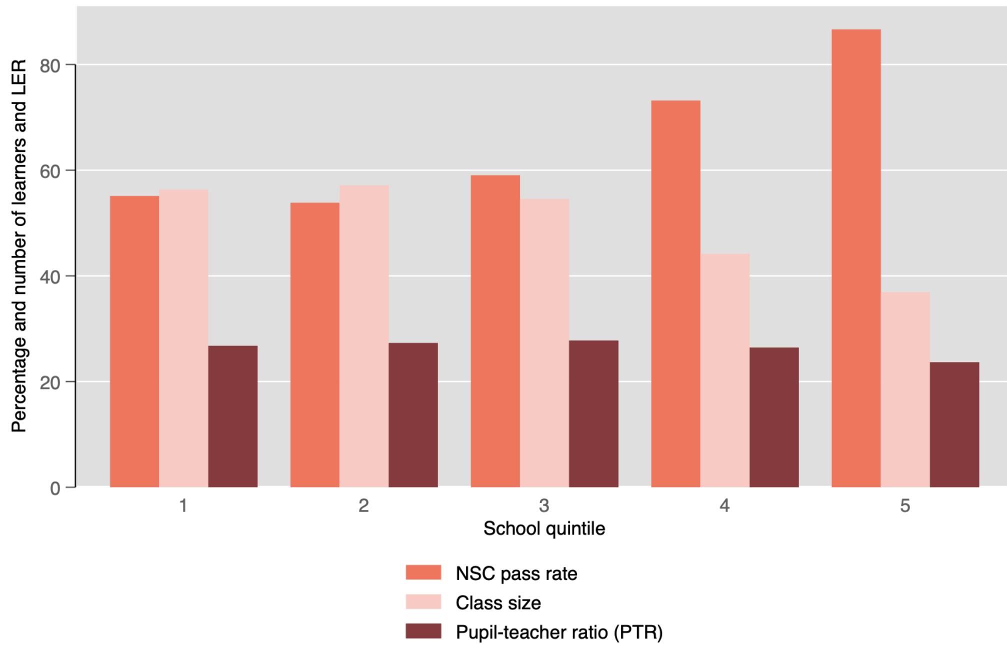


Figure 5: Mean number of learners, teachers, and pupil-teacher ratio by school quintile. Source: 2017/18 SMS and external NSC data.

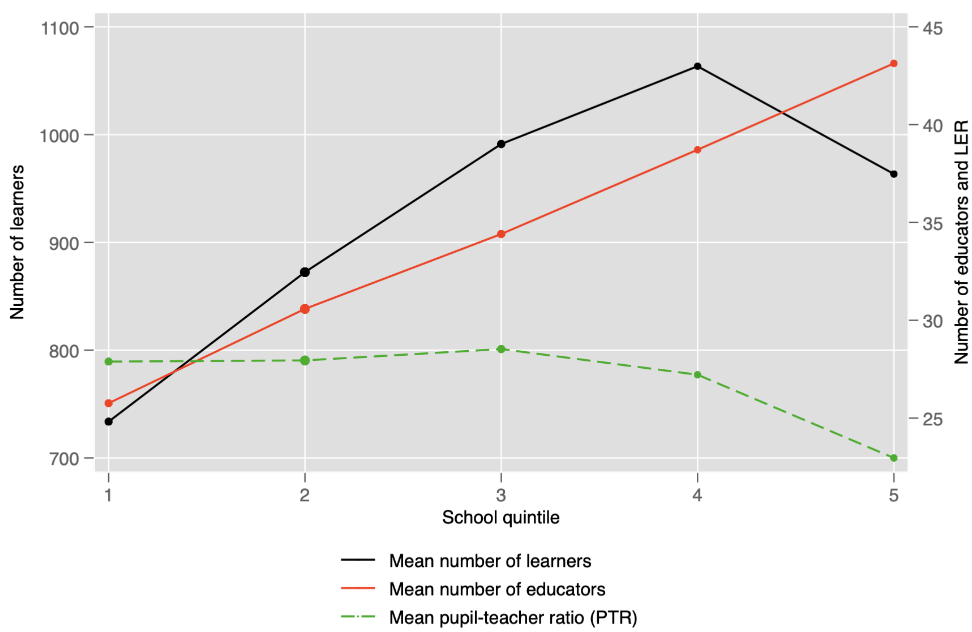
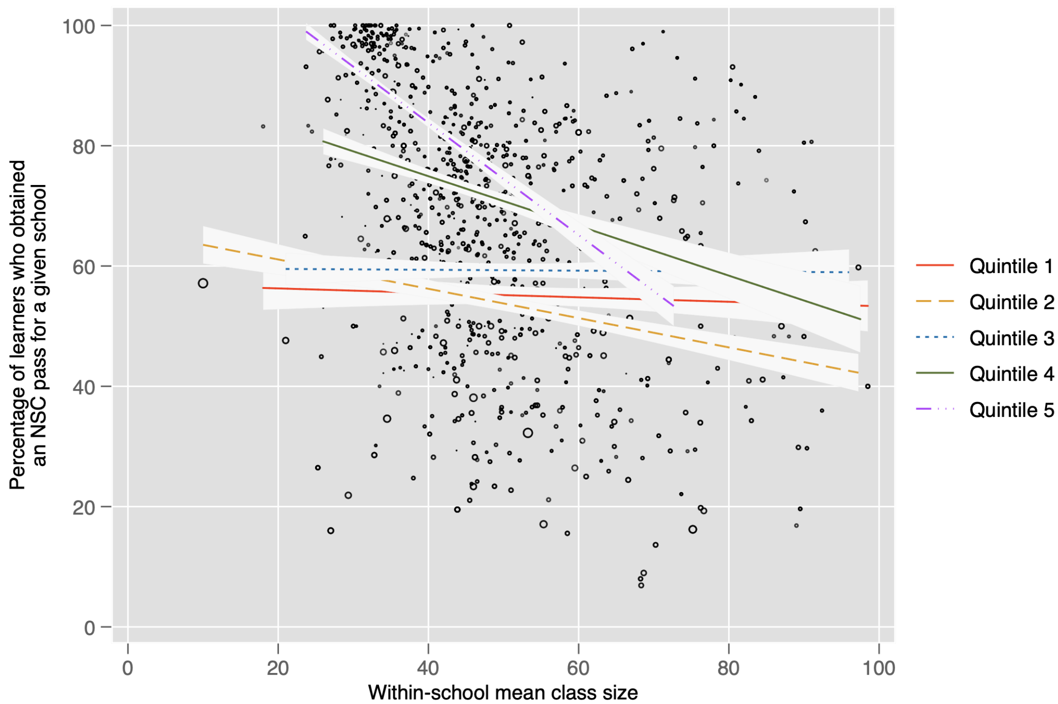


Figure 6: Intra-quintile linear plots of the NSC pass rates and mean class sizes of sampled schools. Source: 2017/18 SMS and external NSC data.



What might be the reason(s) behind better learner outcomes in schools with lower mean class sizes? It is plausible that schools which have higher mean class sizes exhibit other characteristics (which are not evident in schools with lower mean class sizes) which have adverse effects on learner outcomes. If so, then any significant effect of class size may merely reflect the effects of these factors. This is possible given that in SA's context, as expressed by Howie (2005:137), schools which have classrooms with large numbers of learners are also those with poor conditions. This is indicative of the endogeneity concern in the literature arising from the non-random assignment of learners and teachers to schools (Woessman and West, 2006:596; Li and Konstantopoulos, 2016:510), so schools with different class sizes likely differ by several other observable and unobservable factors. Considering the consensus in the literature that teacher quality is one of the most important school-level determinants of learner outcomes (Van der Berg *et al.*, 2016:9; Shepherd, 2011:1; Spaull, 2013:443), Table 1 investigates how several teacher characteristics vary between Quintile 1 to Quintile 5 schools (i.e. high to low mean class size schools). Investigating variation in teacher characteristics by school quintile is important in this regard given that there is empirical evidence of teacher self-selection into schools (Shepherd, 2011:14). The estimates in Table 1 are suggestive of such selection, with wealthier schools employing a greater proportion of teachers with higher qualifications, experience, confidence, and satisfaction, to name a few characteristics. About one in every three teachers in Quintile 1 to 3 schools have a postgraduate degree, as opposed to more than one in every two teachers in the Quintile 5 schools. The average teacher in the latter schools have more than five additional years of teaching experience than the average teacher in Quintile 1 schools. Relative to those in poorer schools, the average teacher in Quintile 5 schools also allocates, according to their self-reporting, eight more hours to teaching in a given week. They are also more likely to have received training on supporting learners with learning difficulties, as well as to teach classrooms where every learner has a textbook. On the other hand, it is perhaps comforting to note that teachers in poorer schools are more likely to participate in externally initiated professional development programmes (administered by the DBE or other formal authorities), and more often use DBE workbooks for classroom instruction.

Table 1: Select school and teacher characteristics by school quintile. Author's own calculations. Source: 2017/18 SMS.

	School quintile					
	1	2	3	4	5	Total
School characteristics						
Pupil-teacher ratio (PTR)	26.796	27.269	27.894	26.025	23.842	26.659
Mean class size (number of learners)	57.081	57.846	55.236	44.139	37.071	52.560
Teacher characteristics						
Matric (%)	1.370	0.980	0.800	0.630	0.800	0.910
Diploma (%)	22.280	24.370	21.780	16.190	7.790	18.980
First Degree (%)	46.350	41.760	42.420	42.010	39.590	42.390
Postgraduate Degree (%)	30.000	32.890	35.000	41.170	51.810	37.720
Took mathematics in matric (%)	66.620	64.330	68.030	73.420	85.320	71.030
Mean years teaching this subject/phase	10.401	11.609	12.028	13.570	15.600	12.203
Very confident in teaching this subject/phase (%)	63.610	67.780	64.190	70.570	79.250	68.600
Mean weekly teaching time (hours)	18.748	19.105	20.207	25.786	26.748	21.106
Teaching multi-grade class (%)	6.710	7.410	7.830	6.500	11.230	8.000
Participated in self-initiated professional development (%)	58.110	52.240	56.200	61.530	64.550	58.030
Participated in school-initiated	65.410	64.670	65.330	72.980	81.380	69.320

Table 1: Select school and teacher characteristics by school quintile (continued). Author's own calculations. Source: 2017/18 SMS.

	School quintile					
	1	2	3	4	5	Total
professional development (%)						
Participated in external-initiated professional development (DBE) (%)	74.160	76.460	73.280	70.850	58.910	71.040
Participated in external-initiated professional development (Other) (%)	38.590	35.380	34.220	31.300	25.480	33.170
Received training on supporting learners with learning difficulties (%)	39.950	39.160	41.670	47.730	53.030	43.840
Very satisfied with support received from HOD (%)	30.360	32.270	32.140	35.970	53.620	36.460
Often use DBE workbooks in classes (%)	8.090	11.210	11.120	14.650	6.930	10.300
Every learner has a textbook (%)	58.240	58.890	64.890	66.690	76.620	64.910

Given this paper's focus on class size, one issue with the data presented in Table 1 is that it presents variation in teacher characteristics by school quintile, as opposed to *class size* quintile. Despite this, the observed inverse relationship between class size and school SES as measured by school quintile categories means that variation in teacher characteristics by *class size* quintile will likely exhibit the same overall patterns when *school* quintile is used: schools with lower mean class sizes (i.e. mainly wealthier schools) tend to employ better quality teachers, so to speak. Indeed, after categorising schools in the data into five groups (quintiles) by mean class size, a strong negative Spearman correlation coefficient of -0.502 (p-value: 0.000) is found for these two quintile variables. Estimates for teacher characteristics by class size quintile are presented in Table 2. As expected, in schools with a mean class size in the top 20% of the class size distribution, the average teacher teaches a class of just under 80 learners and is less likely to (i) have a postgraduate degree, (ii) have taken mathematics in Grade 12, (iii) be very confident in teaching their subject or phase, and (iv) have received training on supporting learners with learning difficulties. These estimates suggest that, because class size appears to be highly correlated with other school-quality related factors, it may be endogenous. The next section investigates this further.

Table 2: Select school and teacher characteristics by class size quintile. Author's own calculations. Source: 2017/18 SMS.

	Class size quintile					
	1	2	3	4	5	Total
School characteristics						
Pupil-teacher ratio (PTR)	20.280	26.190	27.707	28.879	29.068	26.687
Mean class size (number of learners)	30.247	40.249	46.139	53.646	79.250	52.560
Teacher characteristics						
Matric (%)	0.670	0.470	0.460	0.780	1.790	0.910
Diploma (%)	12.390	17.300	19.630	22.620	20.820	18.980
First Degree (%)	38.460	40.150	43.160	44.050	44.460	42.390
Postgraduate Degree (%)	48.470	42.080	36.740	32.550	32.930	37.720
Took mathematics in matric (%)	80.560	77.970	72.330	64.040	65.010	71.030
Mean years teaching this subject/phase	13.460	12.531	12.408	12.126	11.030	12.203
Very confident in teaching this subject/phase (%)	78.160	67.580	66.610	66.280	66.730	68.600
Mean weekly teaching time (hours)	23.456	24.283	23.878	19.168	17.238	21.106
Teaching multi-grade class (%)	9.270	8.970	8.000	5.760	8.330	8.000
Participated in self-initiated professional development (%)	60.530	60.460	58.930	56.240	55.610	58.030
Participated in school-initiated professional development (%)	79.170	71.410	68.750	65.200	65.540	69.320
Participated in external-initiated professional development (DBE) (%)	57.760	70.200	71.310	76.300	75.390	71.040
Participated in external-initiated professional development (Other) (%)	27.930	30.340	30.660	36.940	37.150	33.170
Received training on supporting learners with learning difficulties (%)	52.410	51.950	42.250	39.110	37.840	43.840
Very satisfied with support received from HOD (%)	52.000	36.920	30.070	30.030	36.300	36.460
Often use DBE workbooks in classes (%)	7.330	11.490	12.230	10.790	9.530	10.300
Every learner has a textbook (%)	84.330	70.030	66.690	59.330	52.650	64.910

3.4 Model specifications

As suggested in the previous section, one possible reason why schools with higher mean class sizes are associated with poorer learning outcomes is that such schools may exhibit other characteristics which significantly influence learner outcomes. Class size, in itself, may not have any significant association with learner outcomes once these characteristics are accounted for. If unaccounted for, the estimated relationship of interest will likely be prone to selection bias. In this light, a multivariate regression model can help in this regard by allowing one to control for several possible confounders. Estimated using Ordinary Least Squares (OLS), the basic specifications of the models are as follows:

$$\begin{aligned} Educ_i = \beta_0 + \beta_1 Class\,size_i + \beta_2 Q4_i + \beta 3 Q5_i + \beta_4 Q4_i \times Class\,size_i \\ + \beta_5 Q5_i \times Class\,size_i + \beta_6 \mathbf{X} + \alpha + \epsilon_i \end{aligned} \tag{1}$$

$$\begin{aligned} Educ_i = \beta_0 + \beta_1 PTR_i + \beta_2 Q4_i + \beta 3 Q5_i + \beta_4 Q4_i \times PTR_i \\ + \beta_5 Q5_i \times PTR_i + \beta_6 \mathbf{X} + \alpha + \epsilon_i \end{aligned} \tag{2}$$

where $Educ_i$ is the school-level, learner outcome variable of interest (namely, the NSC pass rate, Bachelor's pass rate, and mean Grade 12 mathematics examination mark for school i), $Class\,size_i$ is school i's mean class size in terms of the number of learners, $Q4_i$ and $Q5_i$ are binary variables equal to one if school i is classified as a Quintile 4 or 5 school respectively and zero otherwise, PTR_i is the PTR of school i, $\mathbf{X}$ is a vector of school-level covariates including province and whether the school is a Dinaledi school,[11] α represents district fixed effects (FE) which are used and chosen over municipality FE because it is plausible to believe that as opposed to municipalities, school districts are linked to processes at the school-level.[12] ϵ_i is the regression error term. Other school-related covariates (such as teacher characteristics) are excluded from the models because they tend to be highly correlated with the Quintile variables and their inclusion therefore removes explanatory power from them. Specifications (1) and (2) are the same except for the focus on class size in the former (but PTR is controlled for) and PTR in the latter (but class size is controlled for). The idea that a high mean class size of a school may be the result of a large number of learners relative to teachers serves as the motivation behind the substitution of class size for PTR in specification (2). Given this paper's focus on how the relationship between learner outcomes and class size (or PTR) may depend on school SES, the coefficients of interest are β_4 and β_5. Relating to the interaction

[11] A Dinaledi school is one which receives financial and other assistance from government subject to certain criteria being met. The intension of the policy is to increase participation and performance in mathematics and physical sciences in historically disadvantaged schools.

[12] It should be noted that, despite their inclusion, the estimates do not differ significantly if these FE are excluded from any of the models.

terms, these coefficients indicate how the conditional correlation between class size (or PTR) and learner outcomes may depend on whether a school is a Quintile 4 or 5 school. Schools in Quintiles 1 to 3 serve as the base variable in this regard, given that it was observed in the previous section that several characteristics of these schools do not differ significantly from one another. The results of these models are presented and discussed in the next section.

4 Model estimates

Table 3 presents the estimates of the models as per the aforementioned specifications. Models (1) to (5) are based off specification (1). Model (1) - the simplest model - highlights a negative unconditional correlation between mean class size and NSC pass rates of schools, significant at the 1% level. However, once controls for school quintiles and their interactions with class size are included in model (2), the significance of this estimate disappears completely and its magnitude tends towards zero. The average Quintile 4 school is associated with a 33.5 percentage point higher NSC pass rate relative to poorer schools, while the coefficient for the average Quintile 5 school is nearly double that of Quintile 4 schools in magnitude (63.2) - both of which are statistically significant. This relationship does not change significantly once other covariates and district FE are controlled for in model (3). In this model, the estimates of interest suggest that, although no evidence for an *overall* class size effect is found, higher mean class sizes in *wealthier* schools are negatively related to the NSC pass rate.[13] This indeed suggests that the relationship between class size and learner outcomes depends on school SES. For the average Quintile 5 school, an increase in the mean class size of 20 learners - roughly the difference in mean class size between Quintile 1 and 5 schools - is associated with a nearly 15.5 percentage point reduction in the NSC pass rate.[14] A similar relationship exists for Quintile 4 schools, although the association is less than half as large and statistically insignificant. This suggests that class size reductions may only be beneficial once other aspects of school quality - such as those that relate to teachers - are addressed. This is in contrast to Woessman and West (2006:726) who propose that the benefits of class size reductions are only realised in countries where the capabilities of teachers appears low. Although not the focus of this paper, also of interest is the significant, positive estimates for the Dinaledi school binary variable in all models.

[13]Similar results hold when individual dummy variables for each school Quintile are included in the model as opposed to the current specification (not shown here).

[14]The presence of an interaction term implies that the association between class size and the dependent variable depends on two coefficients: the coefficient for class size alone, and the coefficient for the relevant interaction term. The association in Model (3) here is computed as follows: 0.014 + (-0.786) = -0.772. Therefore, an increase in the class size of 20 learners implies a 20 x (-0.772) = 15.44 reduction in a school's NSC pass rate, on average.

Models (4) and (5) show that a similar relationship between class size and learner outcomes for wealthier schools holds for alternative outcome variables. In both models, the magnitude of the coefficient of the interaction term is not substantially different for Quintile 4 schools (but it is now statistically significant). For Quintile 5 schools, an increase in the mean class size of 20 learners is associated with a 35.3 percentage point reduction in the Bachelor pass rate - a magnitude double the size of that for the NSC pass rate. Considering Model (5), an increase in the mean class size of 20 learners is associated with a 4.7 and 11.0 percentage point reduction in the mean mathematics mark for Quintile 4 and 5 schools respectively. Additionally, the coefficient for class size (irrespective of school quintile) is significant for both the Bachelor's pass rate and mean mathematics examination mark. Importantly, the signs of these isolated class size estimates are positive, but very small in magnitude and their possible causal effect is thus likely to be negligible.. Turning our attention to PTRs, Models (6) to (8) are based on specification (2) and are suggestive of similar conclusions as the preceding models. Unsurprisingly, the average Quintile 4 and 5 schools are associated with having higher mean mathematics marks and NSC and Bachelor's pass rates. The estimates of interest have the same sign (negative) to those when class size is used; however, the magnitudes are much larger. For the average Quintile 5 school, an increase in the PTR of 10 learners per educator is associated with a 9, 20, and 8 percentage point reduction in the NSC pass rate, Bachelor's pass rate, and mean mathematics mark respectively. Similarly, the equivalent for the average Quintile 4 school is about a 9-13 percentage point reduction. Although the estimates for wealthier schools are considerably larger, the overall PTR estimate (irrespective of quintile) is significant and positively associated with all three outcome variables. Finally, it should also be noted that the included covariates in models (3) to (8) explain more than 50% of variation in the outcome variables.

Considering the previously observed bimodality in the South African education system - a characteristic well-documented in the literature -, it is useful to analyse the relationship between class size and school-level learner outcomes in a bimodal manner. More specifically, it is useful to re-estimate the above regressions for distinct sub-samples of schools. Tables 4 and 5 present the class size and PTR estimates of specifications 1 and 2 for various outcome variables and sub-samples. For brevity, each table presents only the estimates of the variable of interest (mean class size or PTR) with their standard errors as well as each model's coefficient of determination, while all other coefficients are suppressed. Table 4 shows that although class size is significantly and negatively associated with a school's NSC pass rate in general, disaggregation allows one to see that this association is driven by wealthier

Table 3: OLS regressions estimates of specifications 1 and 2 for several outcome variables. Author's own calculations. Source: 2017/18 SMS and external NSC data.

Dependent variable:	NSC pass rate			Bachelor pass rate	Mean maths mark	NSC pass rate	Bachelor pass rate	Mean maths mark
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mean class size	-0.247***	-0.035	0.014	0.050**	0.075***			
	(0.051)	(0.046)	(0.044)	(0.023)	(0.026)			
School quintile 4		33.532***	29.201***	23.314**	23.142***	55.498***	51.142***	49.178***
		(10.330)	(11.037)	(10.064)	(6.856)	(13.620)	(13.757)	(7.459)
School quintile 5		63.194***	57.551***	98.999***	43.921***	61.940***	86.177***	55.803***
		(6.322)	(7.103)	(10.721)	(6.608)	(7.438)	(8.955)	(5.374)
School quintile 4 × mean class size		-0.379	-0.347	-0.331*	-0.309**			
		(0.234)	(0.223)	(0.187)	(0.135)			
School quintile 5 × mean class size		-0.898***	-0.786***	-1.816***	-0.624***			
		(0.163)	(0.184)	(0.289)	(0.187)			
Pupil-teacher ratio (PTR)						0.475***	0.344***	0.618***
						(0.181)	(0.098)	(0.096)
School quintile 4 × PTR						-1.576***	-1.631***	-1.512***
						(0.473)	(0.471)	(0.267)
School quintile 5 × PTR						-1.370***	-2.316***	-1.440***
						(0.296)	(0.395)	(0.236)
Controls	N	N	Y	Y	Y	Y	Y	Y
District FE	N	N	Y	Y	Y	Y	Y	Y
Constant	75.233***	57.939***	58.851***	19.499	22.727***	46.692***	14.288	8.798
	(2.903)	(2.849)	(8.613)	(13.675)	(7.345)	(10.679)	(16.062)	(9.129)
R^2	0.056	0.289	0.505	0.552	0.505	0.519	0.552	0.546
N	4 759	4 759	4 759	4 759	4 759	4 759	4 759	4 759

Table 4: Split-sample class size estimates for several outcome variables. Author's own calculations. Source: 2017/18 SMS and external NSC data.

Dependent variable	Sample				
	Whole	Q1-3	Q4	Q5	Q4-5
NSC pass rate	**-0.133*** **	**0.039**	**-0.550***	**-0.935*** **	**-0.869*** **
	(0.049)	(0.045)	(0.280)	(0.163)	(0.114)
	0.36	0.392	0.567	0.605	0.48
Bachelor pass rate	**-0.125*** **	**0.066*** **	**-0.460*** **	**-1.992*** **	**-1.337*** **
	(0.036)	(0.022)	(0.145)	(0.294)	(0.198)
	0.256	0.373	0.689	0.613	0.479
Mean maths mark	**-0.035**	**0.078*** **	**-0.274** **	**-0.661*** **	**-0.633*** **
	(0.029)	(0.027)	(0.117)	(0.238)	(0.084)
	0.325	0.404	0.564	0.5	0.441
N	4 759	3 088	716	955	1 671

* $p<0.1$, ** $p<0.05$, *** $p<0.01$. R^2 values presented below parentheses.
All regressions include control for a vector of covariates and district fixed effects.

(Quintile 4 and 5) schools and/or the differences between poorer and wealthier schools. When the Bachelor's pass rate and mean mathematics mark are used, this relationship also holds. However, class size is significantly and *positively* associated with both outcomes in Quintile 1 to 3 schools. Importantly though, the magnitude of the estimate is very small and is economically not meaningful. Turning to PTRs, Table 5 presents a similar story, although the magnitudes of the estimates are slightly larger.

5 Conclusion

This paper has sought to empirically describe the distribution of class sizes in the South African public secondary education system and investigate whether the relationship between class size and learner outcomes is dependent on school SES. Using a unique dataset which combines Grade 12 examination data with the newly available 2017/18 School Monitoring Survey, several results stand out. Larger class sizes are concentrated in South Africa's poorest schools, with about 20 more learners in the average classroom in the poorest 60% of schools relative to the wealthiest 20% of schools. This coincides with a more than 30 percentage point inequality in mean NSC pass rates. Quintile 1 to 3 schools are not statistically different from one another in these two aspects, where it is clear that both Quintile 4 and 5 schools exhibit better learner outcomes and lower class sizes on average. The model estimates do not provide significant evidence of an *overall* class size relationship with learner outcomes.

Table 5: Split-sample pupil-teacher ratio estimates for several outcome variables. Author's own calculations. Source: 2017/18 SMS and external NSC data.

Dependent variable	Sample				
	Whole	Q1-3	Q4	Q5	Q4-5
NSC pass rate	**-0.402****	**0.437****	**-0.827**	**-0.931*****	**-1.334*****
	(0.171)	(0.181)	(0.611)	(0.214)	(0.204)
	0.359	0.402	0.531	0.582	0.465
Bachelor pass rate	**-0.713*****	**0.327*****	**-0.532**	**-1.675*****	**-2.125*****
	(0.154)	(0.097)	(0.437)	(0.444)	(0.315)
	0.284	0.381	0.658	0.549	0.477
Mean maths mark	**-0.135**	**0.582*****	**-0.069**	**-0.989*****	**-1.106*****
	(0.113)	(0.087)	(0.353)	(0.234)	(0.162)
	0.326	0.447	0.542	0.555	0.464

* p<0.1, ** p<0.05, *** p<0.01. R^2 values presented below parentheses.
All regressions include control for a vector of covariates and district fixed effects.

However, after showing that class size is highly correlated to other measures of school quality and may be endogenous, the models (which explain more than 50% of variation) show that higher mean class sizes are negatively related to several learner outcome variables *only in wealthier* schools. This suggests that class size reductions may only be effective in improving learner outcomes once *other* characteristics of schools - such as those that relate to teachers or school functionality - are of a sufficient quality. This appears not to be the case in Quintile 1 to 3 schools, where observable characteristics of teacher quality are poorer relative to those in wealthier schools. This information is not new in the South African literature, but the use of this new dataset provides further validation of the existence of this situation. Importantly, the conclusion of this paper is not that class size does not matter. Rather, it is that changes in class sizes or PTRs may not be effective in improving learner outcomes *unless other factors change*. In other words, the severity of these variables seem to merely be indicative of of other important school factors that influence learner outcomes in the South African context. This presents several implications for policy. Although extreme class sizes ought to be alleviated across the SES distribution, the appointment of more teaching personnel can be costly, so it may be preferable to allocate scarce resources to the pedagogical development of teachers in poorer schools rather than first supplementing their numbers in order to reduce class size. As expressed by Hattie (2005:419), although class size reduction may be but one way to improve learner outcomes, it may not be the most effective means to this end in the South African context. Future research ought to investigate these findings in the primary school context, perhaps by linking the SMS data to PIRLS 2016 data using school EMIS numbers.

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6 Appendix

Figure A1: Linear plot of the Grade 12 Bachelor pass rate and mean class size of the sampled schools. Source: 2017/18 SMS and external NSC data.

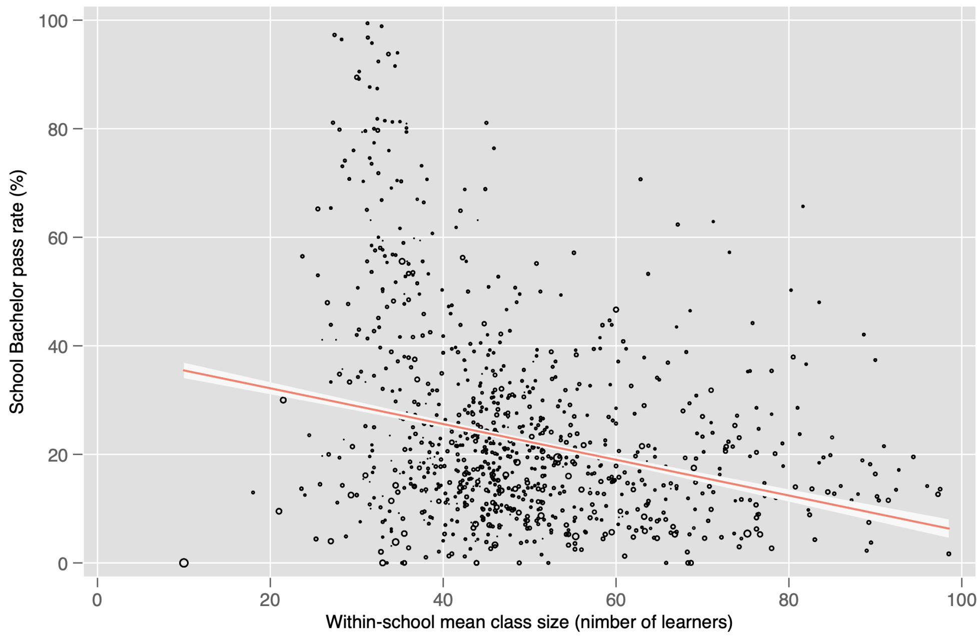

Figure A2: Linear plot of given school's mean Grade 12 mathematics examination marks and mean class size. Source: 2017/18 SMS and external NSC data.