The Effects of Teacher Strike Activity on Student Learning in South African Primary Schools

GABRIELLE WILLS

Stellenbosch Economic Working Papers: 01/14

KEYWORDS: TEACHERS, STRIKES, TRADE UNIONS, STUDENT ACHIEVEMENT, SOUTH AFRICA
JEL: I21, J51, J52, J24

GABRIELLE WILLS
DEPARTMENT OF ECONOMICS
UNIVERSITY OF STELLENBOSCH
PRIVATE BAG X1, 7602
MATIELAND, SOUTH AFRICA
E-MAIL: GABRIELLEWILLS@GMAIL.COM

UNIVERSITEIT
STELLENBOSCH
UNIVERSITY

A WORKING PAPER OF THE DEPARTMENT OF ECONOMICS AND THE
BUREAU FOR ECONOMIC RESEARCH AT THE UNIVERSITY OF STELLENBOSCH

The Effects of Teacher Strike Activity on Student Learning in South African Primary Schools

GABRIELLE WILLS[1,2]

ABSTRACT

This paper investigates whether teacher strikes affect student achievement at the primary school level in South Africa. A cross-subject analysis with student fixed effects is used to eliminate sources of endogeneity bias at the school and student level. Results indicate that teacher strike participation negatively affects learning for students in the poorest three quarters of schools in South Africa. A negative effect size as large as ten per cent of a standard deviation is observed. There is also evidence that more marginalised students, both in terms of socio-economic status and academic performance, are affected most negatively by strike action. However, application of a technique by Altonji, Taber and Elder (2005) indicates that it is not possible to rule out that measured strike effects may be driven by omitted variable bias. The student fixed effects strategy fails to adequately control for unobserved teacher characteristics that may influence both a teacher's decision to strike and student achievement.

Keywords: teachers, strikes, trade unions, student achievement, South Africa
JEL codes: I21, J51, J52, J24

[1] Gabrielle Wills (gabriellewills@gmail.com) is a Ph.D student at the University of Stellenbosch, Department of Economics.

[2] The author would like to thank Neil Rankin, Servaas van der Berg, Rulof Burger and Martin Gustafsson for their insightful comments in crafting this paper. The financial assistance of the National Research Foundation (DAAD-NRF) towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed to the DAAD-NRF.

1. Introduction

In South Africa, teacher unions and industrial action are defining features of the schooling landscape. A history of subjugation of non-white students and teachers during Apartheid, and resulting teacher resistance to this injustice, created a platform for expansive and persistent teacher unionization (Chisholm, 1999). In recent years, schools have seen the most intensive industrial activity among teachers in post-Apartheid history, either in the form of full-blown strike action or 'work-to-rule' behaviour. Consequently teacher unions, and specifically the most dominant South African Democratic Teachers' Union (SADTU), have been heavily criticised for their disruptive effects on the general functioning of the schooling system and on student learning. Recently South Africa's ruling party, the African National Congress, tabled a proposal for the declaration of teaching as an 'essential service' to prevent further losses to schooling days and the general disruptive outcomes of industrial action[3] in schools. However, very little is known about whether teacher strike action has in fact had a negative effect on student achievement.

This paper investigates to what extent industrial action, specifically the intensive strike action of 2007, affects student achievement at the primary school level in South Africa. Using a cross-sectional dataset known as SACMEQ III which tested grade six students in more than one subject area, student fixed effects estimation is used as the primary identification strategy. This follows the work of Kingdon (2006) and Kingdon and Teal (2010) who use this strategy to investigate the effects of teacher characteristics, including teacher union membership, on student learning in India. The approach eliminates some sources of endogeneity bias at the school and student level ubiquitous to education production functions.

The next section provides some background on teachers' unions and industrial action in the South African context, followed by a discussion of international findings on teacher union and strike effects on learning. Sections four to six describe the estimation strategy to be used in the paper, the required data and the model specifications. Results are presented in sections seven and eight. In brief, fixed effects estimations indicate that teacher strike activity negatively affects learning for students in the poorest three quartiles of schools in South Africa. There is evidence from these estimations that more marginalised students, both in terms of socio-economic status and academic performance, are likely to be most affected by strike action. However, application of a technique by Altonji, Taber and Elder (2005) in section nine indicates that it is not possible to rule out that strike effects may be driven by omitted variable bias.

[3] Industrial action is often used as a euphemism for strike activity but its meaning is broader in scope, including work-to-rules, go-slows or overtime bans. In this paper, the focus is to identify, specifically, strike activity effects.

2. Teacher unions and industrial action in South Africa

Historical Context of Teacher Unions

During Apartheid, the provision of unequal education to race groups was an instituted policy mechanism to supress the majority of South Africa's black population. Most notoriously black people were provided 'dumbed-down' education through the then ruling party's "Bantu education"[4] policies. Separate education departments, divided along racial lines, implemented not only distinctive curricula for students but distinctive forms of authority over teachers. As noted by Chisholm (1999), control over white teachers was largely professional in nature where they were consulted in the formation of curricula and given a degree of autonomy in work. By contrast, control over black teachers was intentionally bureaucratic and authoritarian in line with state intentions for social control. Black teachers were closely monitored by inspectors, subject advisors and other representations of white subjugation. In the late eighties, however, large political opposition arose to Apartheid in general and particularly its unjust education policies. The linkage with the Apartheid state of bureaucratic controls over teachers generated considerable teacher resistance which persists today.

There are various different teacher unions in South Africa, but the dominant one is the South African Democratic Teachers' Union, most commonly referred to as SADTU. By 2013 their membership comprised roughly 254 000 teachers, representing two thirds of all teachers. Their presence is extensive not only in terms of membership numbers. The organisational structure of the union facilitates an on-site presence across every school district and in the majority of schools. The next largest teachers' union is the National Professional Teachers Association of South Africa (NAPTOSA) with roughly 45 000 members. Both unions play a role in negotiating conditions of work for teachers in the Education Labour Relations Council but are divergent in their ideologies. NAPTOSA existed in the early days of Apartheid, with typically white leadership and an agenda largely concerned with the professionalism of teachers. By contrast SADTU, having emerged in direct opposition to Apartheid, is understandably more militant, political and concerned with the rights of the 'worker' than promoting professionalism (Chisholm, 1999).

While teacher unions played an important historical role in fighting for positive transformation in education, today their impact on the educational landscape is questionable. Although evidence is largely qualitative in nature, local studies highlight the negative consequences teacher union interference poses for school efficiency. In addition to lost work days due to industrial action or union

[4] The Bantu Education Act of 1953 was the designed plan of former prime minister H.F. Verwoerd. In his own words he said, *"There is no place for [the Bantu] in the European community above the level of certain forms of labour. It is of no avail for him to receive a training which has as its aim, absorption in the European community* (Senate, 1954)*".* The Bantu Education system was established to educate black youth only to a level where they could operate as labourer, worker and servant.

meetings, efficiency losses may take the form of interference in the appointment of school managers, the demand or supply of teachers and the way in which school manager effectiveness is compromised in an environment of union-management tensions (NEEDU, 2012; Patillo, 2012). Furthermore, due to SADTU's historical links with the liberation movement and its large membership, they have considerable influence over national policy decisions in education. Beyond advocating for improved pay, benefits and conditions of work, they remain vehemently opposed to any national policies implying forms of monitoring or control of teachers' work.

Despite this proliferous involvement of unions in schools and in (arguably) the functioning of the Department of Education, no quantitative research has explored union effects in the South African schooling environment. This is largely due to data limitations in identifying unionized teachers from non-unionized teachers in available school datasets. As a start, this research attempts to investigate the impacts unions pose for student achievement through lost worker days due to teacher strike participation.

Recent Teacher Strikes in South Africa

South African teachers appear to engage in higher levels of strike action compared with their counterparts in other African states and with workers in other local sectors.

Strike activity was more prevalent amongst South African teachers in 2007 compared with teachers in fourteen other South Eastern African states. Estimates from SACMEQ III dataset in Table 1 indicate that South African teachers were absent for an average of 11.7 days in the 2007 year due to teacher strikes compared with the regional average for other countries of 0.16 days. The second highest occurrence of teacher strike activity was in Zimbabwe, where teachers were absent for about two days. For the remaining thirteen countries, strike activity was virtually non-existent.

A notable feature of the table is that the teacher strike of 2007 in South Africa was the dominant reason for high levels of teacher absenteeism[5] when compared with other countries. The data indicates that by September 2007 when the SACMEQ survey was administered, teachers had been absent for on average nineteen days in that calendar year. However excluding days absent for strike participation, teacher absenteeism in South Africa fares well against the regional average. Second to teacher strikes, own illness was the most common reason for absenteeism, followed by 'official

[5] It is important to note that teacher absenteeism figures, including strike activity absence, are likely to be underestimated in SACMEQ III for two reasons. First, absenteeism is self-reported in teacher questionnaires and is likely to be underestimated. Second, the survey was administered in September 2007 and therefore total recorded teacher absenteeism excluded absence that would have occurred in the remaining three months of the year (the school year coincides with the calendar year in all these countries). Underestimation of absenteeism in SACMEQ III is also suggested when compared with other data. Using the 2008 Khulisa Consortium audit of ordinary schools datasets, for example, an HSRC report provides a 'conservative' estimate that on average between twenty and 24 days a year of regular instructional time were lost by each teacher (Reddy et al., 2010).

business', maternity leave and attending funerals. This is seen graphically in the stacked bar chart of Figure 1 which presents total average days that teachers across fourteen[6] countries were absent in 2007 for a list of absenteeism reasons.

In the domestic context, teachers also have engaged in high levels of strike activity when compared with other sectors. Between 1995 and 2009, SADTU was responsible for 42 per cent of total worker days lost in South Africa over the fourteen year period. This was largely attributed to a long and intensive strike in 2007 which involved nearly one million public service workers from seventeen unions, including nurses, teachers and other civil servants (Education Labour Relations Council, 2010). Teachers, however, formed a dominant role in this strike. Union members came out in support of a demand for an across-the-board increase of twelve per cent in salaries, as well as increases in health and housing benefits. The strike started on 1 June 2007 and lasted 28 days. Subsequent years, particularly 2010, have seen equally intensive strike action by teachers.

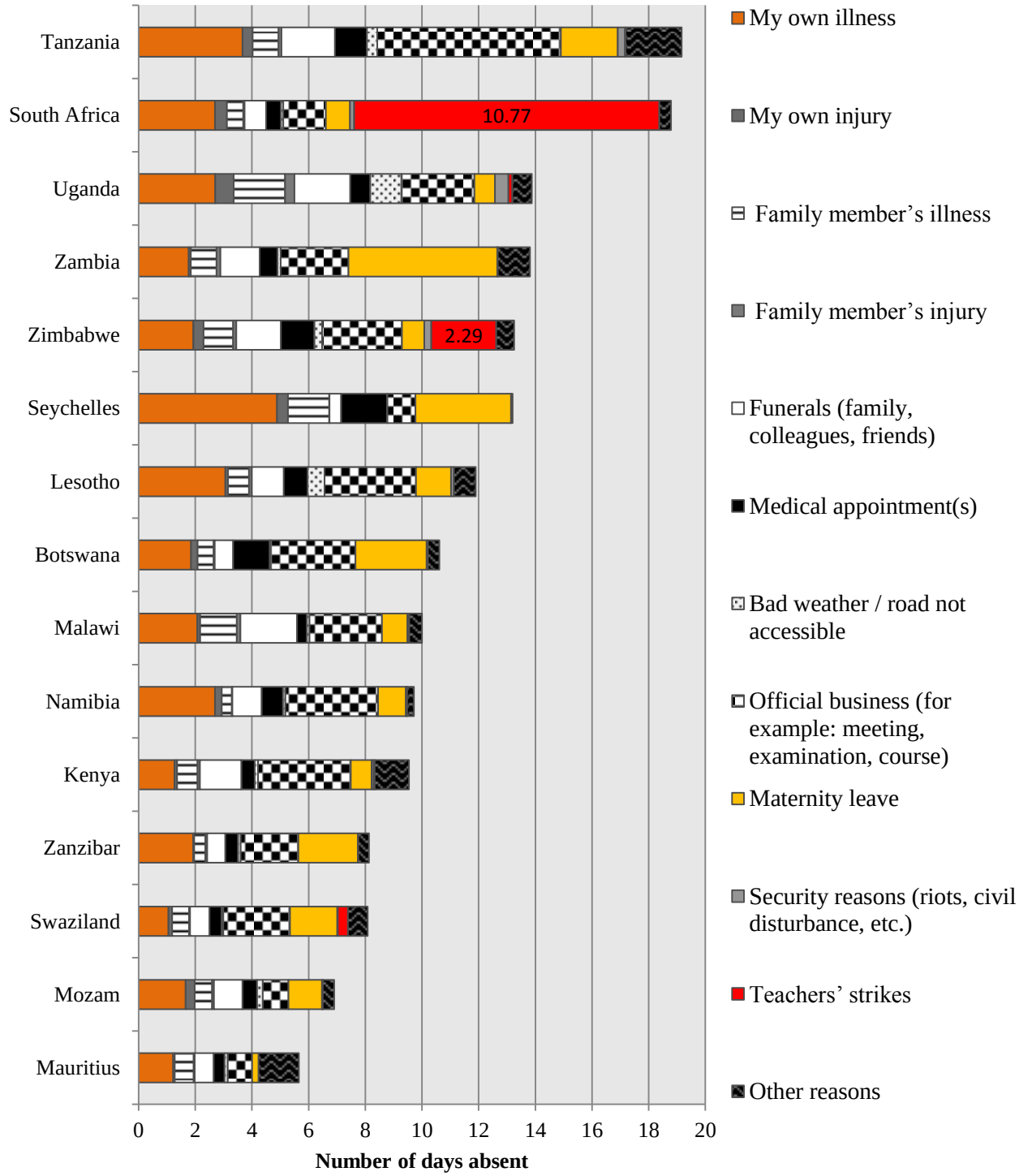
Table 1: Average number of days a teacher is absent for strike activity and total average days of teacher absenteeism for 14 South East African Countries, SACMEQ III 2007

	Days absent for teacher strikes			**Total days absent**		
	Mean	**Standard Error**	**Number of teachers**	**Mean**	**Standard Error**	**Number of teachers**
South Africa	10.771	(0.384)	1158	18.791	(0.784)	1158
Zimbabwe	2.290	(0.248)	319	13.248	(1.340)	319
Swaziland	0.358	(0.053)	368	8.082	(0.746)	368
Uganda	0.138	(0.072)	741	13.872	(0.941)	741
Kenya	0.039	(0.026)	763	9.538	(0.594)	763
Malawi	0.036	(0.036)	267	10.000	(0.909)	267
Tanzania	0.020	(0.017)	637	19.166	(1.130)	637
Zambia	0.009	(0.009)	279	13.814	(2.078)	279
Namibia	0.005	(0.003)	831	9.714	(0.573)	831
Mozambique	0.002	(0.002)	882	6.899	(0.443)	882
Botswana	0.000	-	421	10.616	(1.106)	421
Lesotho	0.000	-	298	11.894	(0.855)	298
Mauritius	0.000	-	479	5.652	(0.365)	479
Seychelles	0.000	-	115	13.200	(1.971)	115
Zanzibar	0.000	-	710	8.133	(0.840)	710
Regional average	**1.554**	**(0.061)**	**8 268**	**11.684**	**(0.248)**	**8 268**
Regional average excl. SA	**0.158**	**(0.019)**	**7 847**	**10.608**	**(0.255)**	**7 847**

Notes: Calculations account for probability weights and stratification by region in sample design.

[6] Zanzibar is a territory of Tanzania with its own school education system, therefore only fourteen *countries* are represented in the table.

Figure 1: A cross country comparison of self-reported days absent among teachers by reasons for absenteeism, SACMEQ III 2007



The adverse impacts of teacher strikes in South Africa are obvious in terms of school closures, disruptions to teaching programmes and exam timetables. Teacher strikes are also occasionally characterised by riots and outbreaks of violent protest with unionized teachers intimidating schools that remain open or those teachers that resist calls to down tools (Patillo, 2012). Furthermore, strike action among teachers, specifically the militant activities of SADTU[7], have created negative sentiment about teachers in a country that can ill-afford the de-professionalization of teaching where capable and qualified teachers are desperately needed. However, a fundamental question remains as to whether and to what extent teacher strike activity actually affects student achievement in South Africa? While parties are debating the ethics behind declaring teaching an essential service, are there grounds to believe that this proposed policy will in fact prevent lost learning?

Using the SACMEQ III cross-sectional dataset, this paper investigates to what extent teachers' strike action in 2007 impacted on student achievement in South African primary schools. It is possible to identify the impacts of the 2007 strike, even in a cross-sectional framework, because the strike did not affect all schools and teachers uniformly. While unions may officially call for a month long strike, the number of days individual teachers choose to strike is variable across and within schools.

3. International literature: Effects of teacher unions and industrial action on student achievement

Studies more commonly investigate the effects of union membership than teachers' industrial action on student achievement. In the developed world context, mixed evidence exists on the impacts of teacher unions on the education production function. In the United States, for example, average negative effects of union membership on high school dropout rates are found by Hoxby (1996) yet positive effects on college entrance scores are identified by Grimes and Register (1991) for black American students. In the developing world context, it is argued that unions and specifically teacher unions contribute to 'quiet corruption', undermining efficiencies in the production of education as they alter the rules of the game and capture gains at the expense of the intended beneficiary (World Bank, 2010). There is little empirical evidence, however, in this regard with the exception of work by Kingdon and Teal (2010), who identify negative effects of union membership in India on grade ten student achievement scores.

Mixed evidence of the direction and size of effects of teacher union membership on student achievement is expected where under different theoretical models it can lead to higher or lower student achievement. In Hoxby's (1996) theoretical analysis of how teacher unions affect the

[7] SADTU's historically militant culture has translated into uncontrolled and sometimes violent behaviour among members during periods of strike action, threatening not only teaching but the safety of students and teachers in recent years (Patillo, 2012).

education production function, she identifies three different pathways through which this may occur. First, unionization may influence the overall budget for school inputs. Second, the budgetary mix across alternative inputs may be manipulated through union demands. The third effect is efficiency related, where the productivity of schools' inputs is altered through unionized teachers' daily engagement with school inputs. Ultimately how altered levels and allocations of inputs translate into student achievement gains or losses depends on whether unionized teachers are 'rent-seeking' or 'efficiency-enhancing' in their behaviour. Efficiency-enhancing union teachers are assumed to have the same objective function as parents, desiring to maximize student learning; but they have expert knowledge about those inputs and use of inputs that are likely to produce higher student achievement. Rent-seeking unionized teachers are assumed to have a different objective function to parents or their employer, militating for school inputs and policies that maximize their own objectives rather than those of the students or parents. For example, rent-seeking union members may lobby for higher teacher salaries at the expense of policies that directly benefit student achievement. In the process they may engage in industrial action, reducing their levels of teaching effort and efficiency which results in lower expected student achievement.

While theory supports the possibility of positive, negative or no union membership effects on schooling outcomes, both theory and logic predicts that rent-seeking industrial action will be accompanied by lower student achievement. Logically it is expected that if students are not in school or being taught by teachers, learning cannot take place. Empirically, however, international evidence of the effect of teacher strikes on learning is contradictory where in addition to negative strike effects (Baker, 2011; Belot and Webbink, 2010) studies identify no strike effects (Zwerling, 2008).

In reconciling the contrasting results, explanations for no observed effects of strike action on student achievement are at best vague. Some argue that teachers make up for work stoppages so that total instructional time is unchanged and therefore overall student learning unaffected (Zwerling, 2008). The most plausible explanation, however, is provided by Baker (2011), who argues that the lack of identification of negative effects in previous studies is related to estimation strategies relying on cross-sectional data that do not sufficiently control for various sources of endogeneity bias. As with most production function estimation, identification problems are common when estimating strike activity effects on student achievement. It is difficult to differentiate between true effects and bias generated through various sources of endogeneity that exist at the district, school, teacher and student level. For example, in school districts where administration is weak, affecting school functionality and ultimately student achievement, strike activity may be more prevalent as teachers attempt to secure better job conditions for themselves. At the school level unobserved school characteristics that influence a teacher's decision to strike may themselves affect the education production function. As identified by Hoxby (1996), industrial activity in a school may intensify, for example, where school

administrators are considered incompetent. Further challenges for estimation are that students may match non-randomly to schools and to teachers and teachers' unobserved characteristics may themselves be correlated with their decision to strike (Kingdon and Teal, 2010).

Although panel data is typically required to control for some of the aforementioned sources of endogeneity, cross-sectional school survey data that tests students in more than one subject can be exploited to achieve some of the gains associated with panel data. This cross-subject analysis using student fixed effects is a technical innovation exploited by Kingdon (2006) in estimating the effect of teacher characteristics on the production of education in India and later applied, specifically, to identifying teacher union effects on student achievement in India (Kingdon and Teal, 2010).[8]

4. Estimation strategy

Consider the following equation, where achievement scores of student i in subject j and attending school k is modelled as a function of student, school and teacher inputs:

$$A_{ijk} = \alpha + \beta X_{ik} + \gamma T_{jk} + \theta strike_{jk} + \delta S_k + (\mu_{ij} + \varepsilon_{jk} + \eta_{jk}) \qquad (1)$$

A vector of student characteristics for the ith student in school k is represented by X_{ik} and a vector of school characteristics in the kth school is represented by S_k. Where data is available for multiple teachers, teaching different subjects, their characteristics are not subsumed within S at the school level as is the case with many education production function estimations. Within the school, teacher characteristics vary so that teacher characteristics, T, for the jth subject are observed in school k. Furthermore, where teacher characteristics are assumed to be independent of whether they participate in a strike, we observe strike participation of the jth teacher in school k, $strike_{jk}$. Unobserved characteristics of the student, the subject teacher and the school are reflected in the composite error term $(\mu_{ij} + \varepsilon_{jk} + \eta_{jk})$.

Initially, ordinary least squares (OLS) estimates are used to estimate equation (1) to identify the relationship between a teacher's strike activity and student achievement. However, noting the shortcomings of the OLS approach in addressing endogeneity bias, fixed effects estimates are then provided.

[8] Clotfelter, Ladd and Vigdor (2007) also exploit this strategy to examine the effects of teacher credentials on student achievement in North Carolina. Altinok and Kingdon (2012) provide another example of the application of the student fixed effects estimation approach to identify class size effects on learning for a number of countries. They exploit student testing in multiple subjects in available TIMMS data to implement this identification strategy.

Student fixed effects model

In a district or school fixed effects equation, observable and unobservable characteristics at the school and district level are differenced out of the equation. This removes some potential correlation bias between unobserved district and school level factors and the variable of interest, namely strike action. However, it does not remove student unobservables from the estimation which may be correlated with teachers' participation in strikes. The student fixed effect approach using a cross-subject analysis goes a step further. Using this approach one estimates an across-subject, within-student achievement production function which is akin to the more familiar panel data fixed effects approach (Kingdon, 2006). In comparison to an achievement production function estimation using panel data where achievement is modelled by considering variations within-students across-time, Kingdon (2006) notes that here a within-student across-subject equation is estimated. The advantage of this method is that one controls for all subject-invariant student and family unobservables and examines whether the industrial action of different subject teachers in a school is related to a student's marks across those subjects in a specific year.[9]

As Kindgon (2006) explains, in a simple case of two subjects, unobservables are differenced out of the estimation as follows:

$$A_{i2k} - A_{i1k} = \gamma(T_{2k} - T_{1k}) + \theta(strike_{2k} - strike_{1k}) + \{(\mu_{i2} - \mu_{i1}) + (\varepsilon_{2k} - \varepsilon_{1k}) + (\eta_{2k} - \eta_{1k})\} \quad (2)$$

Assuming that school unobservables and student unobservables are subject invariant such that both μ and η do not have a j subscript, then within the k^{th} school equation (2) reduces to equation (3). Student and school (and district) heterogeneity is effectively differenced out of the equation in a cross-subject student fixed effects estimation.

$$A_{i2} - A_{i1} = \gamma(T_2 - T_1) + \theta(strike_2 - strike_1) + \{(\varepsilon_1 - \varepsilon_2)\} \quad (3)$$

Major limitations of the student fixed effects estimation

This estimation strategy has the advantage of removing some of the confounding effects of unobserved heterogeneity in student and school characteristics. However it eliminates some but not all sources of bias. In particular, it does not remove heterogeneity in teacher characteristics where

[9] This approach has an advantage over panel data estimation in that it avoids the problem of non-random attrition of students/teachers over time (Kingdon and Teal, 2010). However, a similar attrition arises in the SACMEQ data where some students were not tested in all subjects.

unobserved teacher characteristics $(\varepsilon_1, \varepsilon_2)$ may be both correlated with a teacher's decision to strike, $strike_{jk}$, and student achievement, A (Kingdon, 2006; Kingdon and Teal, 2010).[10]

In other words the requirement that

$$\mathrm{E}[(\varepsilon_2 - \varepsilon_1)(strike_2 - strike_1)] = 0 \tag{4}$$

for causal inference is not completely satisfied even using student fixed effects. This is a major limitation of the approach as the estimation of the strike effect requires that a teacher's unobserved characteristics be unrelated to his or her decision to strike in order to make causal inferences about the effects of strike action on student achievement. Kingdon and Teal (2010), in addressing this concern in the context of union effects, supplement their analysis using a technique proposed by Altonji, Elder and Taber (2005) to investigate the sensitivity of estimates to omitted variable bias. Section nine provides a discussion of this technique with application to interpreting estimation results.

5. Data

Using the student fixed effects estimation strategy requires a dataset that must satisfy two conditions. First, it requires cross-sectional data with at least two subject test scores per student. Another condition is that there must be reasonable variation in the variable of interest, in this case teachers' strike activity by subject (Altinok and Kingdon, 2012)

A dataset that satisfies these criteria is the third Southern and East African Consortium for Monitoring Educational Quality (SACMEQ III) survey. SACMEQ is a consortium of fourteen ministries of education from Southern and Eastern African countries, including South Africa.[11] Since its inception, SACMEQ has conducted three large-scale, cross-national surveys of schooling at the grade six level together with UNESCO's International Institute of Educational Planning (IIEP). The most recent of these is SACMEQ III where data was collected in the last quarter of 2007 for over 61 000 students across the fourteen countries (SACMEQ, 2010).

[10] Furthermore, the assumption that unobserved student characteristics are invariant across subjects is questionable. Student ability may vary across subjects; for example it is plausible that student ability in language exceeds ability in math. In this case, the μ is not differenced out of the equation and may be correlated with a teacher's strike activity and student achievement. The presence of subject-varying student ability can then remain a source of bias in the estimation (Kingdon, 2006). Another limitation of this approach is that the fixed effects approach effectively differences out variables, where differencing may introduce possible measurement error attenuation bias.

[11] Other education ministry members are from Botswana, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, Swaziland, Tanzania (mainland), Tanzania (Zanzibar), Uganda, Zambia, and Zimbabwe. The mission of the organisation is to support education improvements by providing technical skills, data and research for monitoring and evaluating school quality in the member-based basic education systems.

The distinct target population of the survey was all students at the grade six level in 2007; however, the survey was also concerned with describing schools and teachers.[12] In South Africa specifically, 392 schools were sampled and a total of 9 071 students and 1 158 teachers were surveyed. In addition to collecting information on students' background and various school characteristics, the SACMEQ data provides three different achievement scores for students in health, reading and mathematics. At the grade six level in South Africa, each of these testing areas are covered in at least three of the eight compulsory subjects as determined by the Revised National Curriculum. Health, specifically, is one of five focus areas in the compulsory subject, Life Orientation, and therefore covered in the school curriculum (Department of Education, 2003).

In a primary school environment, it is not unusual for one teacher to provide instruction in more than one subject area, which reduces the available across-subject observations in a student fixed effects estimation. This may eliminate the potential for estimating the relationship between student achievement and teacher characteristics *within* the school as teacher characteristics do not vary by student within schools but are essentially school level characteristics. Fortunately, the majority of the student sample in South Africa is taught the three subject areas – mathematics, reading and Life Orientation (including health) – by more than one teacher. This is not the case for many other countries in the dataset. Out of a total sample of 9 071 South African students in the sample from 392 schools, only 743 students from 32 schools had a single teacher providing instruction in all the three subjects, while 2 717 students had two different teachers for the three subjects and 5 611 students had three different teachers for the three subjects. Background questionnaires are provided to students' teachers in each of these subject areas so that it is possible to link the characteristics of different subject teachers within a school to the achievement of their students in each subject. For each student there are as many rows of data as they have different teachers for each subject.

To facilitate the comparison of student achievement scores across the three different subjects, scores in each subject are converted to a standardized score. The standardized score is obtained by subtracting the national mean score in that subject from the individual score and dividing it by the standard deviation of the score in that subject. By construction, standardized achievement scores in reading, mathematics and health have a mean of 0 and standard deviation of 1.

[12] With respect to the sampling strategy, SACMEQ III was stratified using both explicit and implicit strata. The explicit stratification variable was 'region'; in the South Africa case this is analogous to the nine provinces. The implicit stratum is school size. To have greater control of the final sample size, sampling of schools was conducted using probability proportional to size, where a simple random sample of a fixed number of students is selected within each school. Data collectors were responsible for the selection of students within a school rather than school managers or teachers who may choose the brighter students to participate and bias the sample (SACMEQ, 2010).

6. Model specifications and descriptive statistics

Recalling equation (1), two key explanatory variables of interest are used in this study to identify the effect of teachers' strike action, $strike_{jk}$, on student achievement scores. The first is a dummy variable that takes on a value of one if a teacher reports being absent due to teacher strikes for at least one day during the year 2007. Using this definition, a total of 73 per cent of teachers in South Africa participated in strike activity in 2007. The second variable is continuous and reflects the total number of days a teacher was absent due to strikes.

The pooled statistics in Table 2 disguise considerable differences in union activity and the militancy of industrial action across different parts of South Africa's schooling system that were governed by distinct education departments during Apartheid. The first is a system of schools serving a previously disadvantaged population of primarily black students and the second is one of historically privileged schools with a predominantly white student population. Schools serving the coloured and to a lesser extent the Indian population during Apartheid are less systematically distributed between these two sub-systems. Unfortunately, there are no indicators for the language, race or former education department classification for schools in the SACMEQ III data set. A commonly used *proxy* to identify these two systems is the average wealth status of the schools' students, distinguishing between the poorest 75 per cent and wealthiest 25 per cent of schools.[13]

Strike activity is more prevalent in the poorest three quartiles of schools where almost 80 per cent of teachers engaged in at least one day of strike activity in 2007 compared with 57 per cent of teachers in the wealthiest quartile of schools. The duration of strike activity is also considerably higher in the poorer schools where teachers were on average absent for 13.2 days for the 2007 strike compared with only 4.3 days among teachers in the wealthiest schools. Figure 2 also emphasises the stark differences across the two groups of schools, presenting a cumulative percentage graph of teachers' strike activity. It shows that in the wealthiest schools, 80 per cent of teachers were on strike three days or less in 2007, while 80 per cent of teachers in the poorest schools were on strike twenty days or less. Consistent with higher numbers of lost worker days due to strike activity in poorer schools, principals in these schools report more school closures due to disruptions, at 9.3 days per year compared to 3.8 days per year in the wealthiest schools.

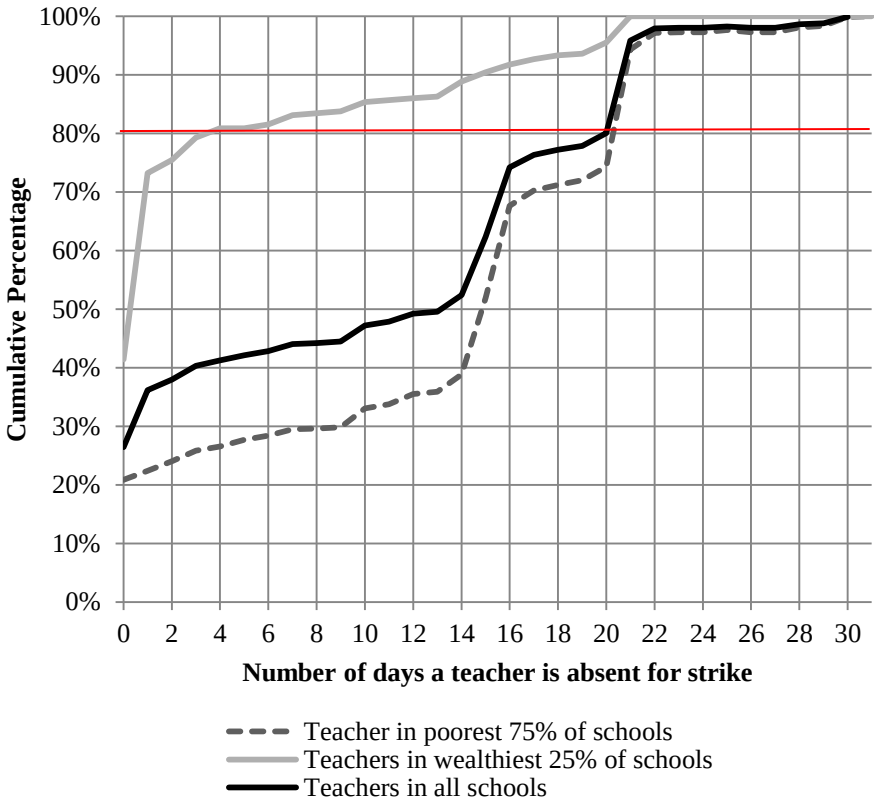
[13] The socio-economic status (SES) of each student is determined by applying principal components analysis to data on asset-ownership in a student's home to derive an asset-based SES index per student. This is then averaged at the school level to determine the school SES status. By comparing student performance distributions by race and language against distributions by SES using different schooling datasets, Spaull (2012) finds that student performance in the poorest 75 per cent of schools matches closely with that in the previously disadvantaged system of schools.

Table 2: Teacher strike participation and school disruptions by the wealth status of schools, SACMEQ III 2007

	Teachers - poorest 75% of schools	Teachers - wealthiest 25% of schools	Teachers - all schools
At least 1 day absent for strike	0.797	0.572	0.734
	(0.019)	(0.042)	(0.018)
Zero days absent for strike	0.203	0.428	0.266
	(0.019)	(0.042)	(0.018)
Total days teachers are absent for strike	13.253	4.310	10.759
	(0.390)	(0.841)	(0.386)
Number of teachers	**844**	**314**	**1 158**
	Schools – Poorest 75%	**Schools – Wealthiest 25%**	**All schools**
Number of days school is closed due to disruptions (including teacher strikes)	9.306	3.779	7.960
	(0.609)	(0.684)	(0.506)
Number of schools	**297**	**95**	**392**

Notes: Standard errors are in parentheses. All calculations account for probability weights and stratification by province in sampling design. The wealth status of the school is determined by constructing an asset-based socio-economic (SES) index for students and averaging student level SES scores at the school level to determine the schools' wealth status.

Figure 2: Cumulative percentage graph of teachers' strike absenteeism by the wealth status of the school, SACMEQ III 2007



The difference in strike activity behaviour across the poorest and wealthiest schools is consistent with a growing economics literature supporting a bimodal schooling system in South Africa. There is increasing consensus that two separate data generating systems exist where pooling all schools together disguises marked differences in the 'production' of learning across the two systems (Spaull, 2012; Taylor, 2011; Van der Berg, 2008). Industrial action may also have heterogeneous impacts on student achievement across the two systems. For this reason OLS and fixed effects regressions are run separately for the poorest 75 per cent of schools and the wealthiest 25 per cent of schools in addition to the full school sample.

Following Kingdon and Teal (2010), teacher characteristics in the regressions are distinguished into two groups: those variables that are most likely determined prior to joining a teachers' union and those determined after unionization. Motivating this approach is the possibility that teacher characteristics may be influenced by unionization and militancy of a teacher's union involvement, so that including them in the production function could bias down the effect of strike action observed. The group of teacher variables most likely to be determined prior to union involvement is represented by T_{jk}:

$$T_{jk} = \{degree_{jk}; male_{jk};\ preservice_{jk};\ age_{jk}\}$$

where $degree_{jk}$ reflects whether the teacher has completed a tertiary education (at least a first degree), $male_{jk}$ indicates a teacher's gender, and age_{jk} their age. $Preservice_{jk}$ indicates whether a teacher has pre-service training. In SACMEQ III pre-service training is captured as a categorical variable where teachers can report one year or less, two years, three years or more than three years of training. The majority of teachers have more than three years of training so this has been used as the reference category with indicator variables included for one year or less of training, two years and three years. Information on other teacher characteristics more likely to be determined after unionization and potentially influenced by union involvement are represented by T'_{jk} :

$$T'_{jk} = \begin{Bmatrix} experience_{jk}; home_{jk}; absenteeism_{jk}; \\ equipment_{jk};\ effort_{jk};\ testscore_{jk} \end{Bmatrix}$$

$Experience_{jk}$reflects the total number of years of teacher experience, and $home_{jk}$ is a proxy for the wealth of the teacher taking on a value of one if a teacher reports that his or her home is in poor condition or in need of major repairs and zero otherwise. Three continuous variables are included as controls for a teacher's $absenteeism_{jk}$ which include the self-reported number of days they have been absent from school for their own illness, funerals and 'official business' such as courses, meetings or exams in the current year. Two variables are used to capture teaching $equipment_{jk}$ identified by each teacher in a subject specific class. The first is a standardised index of teaching

equipment as well as an indicator variable for whether there are enough sitting places for students in the classroom. Three different variables have been used as proxies for teachers' $effort_{jk}$, including the total weekly self-reported hours spent on lesson preparation and marking outside of school, an indicator variable for whether a teacher gets parents to sign children's homework and another indicator variable for whether a teacher meets monthly with the school principal for teaching advice or coaching. Finally, teachers' subject specific test score results are included as a proxy for their ability or specifically, teacher content knowledge.

For comparability of subject specific tests, the continuous variable for a teacher's test score takes on the standardized value of their test score for the subject taught. Unfortunately, 164 of 1 558 teachers did not complete the subject specific teacher tests in SACMEQ III, reducing the sample size available for estimations.[14] Whether a teacher completed the tests provides information in itself about some unobserved characteristics of the teacher, such as willingness to comply. Therefore, before restricting the sample to include a continuous score, an indicator variable for whether the teacher completed the test is included in a specification.

Descriptive statistics of these identified teacher variables are provided in the Appendix, Table A 1, which shows means and standard deviations of each of the variables described. In addition, the table describes the set of student and school characteristics included in the OLS estimations.

The next section reports the results of OLS and fixed effects estimations. Both OLS and fixed effects estimates control for probability weights in sampling and standard errors are corrected for clustering of errors between subjects within a student. The first set of regressions uses the indicator variable for whether a teacher is absent at least one day for strike activity and four specifications are run. In the first specification the only teacher characteristic included is the variable of interest, teacher strike participation. In the second specification, teacher characteristics presumably determined prior to union involvement (T_{jk}) are included while the third specification extends the set of teacher characteristics to include additional teacher characteristics (T'_{jk}), except teacher tests scores. The fourth specification limits the sample to those students whose teachers completed a subject specific test and includes this teacher test score as a covariate. All regressions include indicator variables for the subject test in question where mathematics is the reference category.

[14] In SACMEQ II administered in 2001, SADTU strongly opposed teacher testing to the point that no teacher tests were administered in South Africa, unlike in the other participating SACMEQ countries. On initial inspection of the data it was expected that non-test takers in the subsequent 2007 SACMEQ III would be likely to be a select group of teachers who are more likely to be unionized and engage in industrial action. This is not the case. In support of teacher testing in SACMEQ III, 2007, the then minister of education, Naledi Pandor, simply said that taking the test was not a question of labour relations, but of professionalism. Teachers would be tested even if the unions objected. According to some anecdotal evidence, the unions were perhaps caught off guard and did not raise strong objections to testing. For this reason, union attitudes to testing may not have had such a great effect on who was tested.

7. Results: Average effects of teacher strike participation

Tables 3 to 5 show OLS and fixed effects results for the full sample of schools, the poorest three quartiles and the wealthiest quartile of schools. For brevity sake, the tables only show coefficients on variables common to both the OLS and student fixed effects estimations, namely coefficients on teacher variables and subject dummies. The full set of covariate effects for student and school characteristics in the OLS estimations can be seen in the Appendix, Table A 2.

For the full sample of schools, the OLS results in Table 3 show a positive average effect of teacher strikes on student achievement in the first specification, but the coefficient is insignificant. Moving to the student fixed effects estimation, a statistically significant negative strike effect is observed in specification one. With the inclusion of teacher characteristics in specifications two to four, the fixed effect estimate becomes less negative and statistically insignificant. In contrast to the overall insignificant strike effect, various other teacher characteristics have significant effects on student test scores. Significant positive effects are observed for having a teaching degree, engaging with the school principal to get advice on teaching and having higher teacher test scores in specification four of the fixed effects estimation. Teacher effort as signalled by hours spent on lesson preparation and marking is also positive and significant. Notable is that having two or three years of pre-service teacher training as opposed to a year or less, or alternatively more than three years of pre-service training, is positively associated with learning with large coefficient sizes observed. By contrast, in OLS estimates teacher pre-service training has consistently no or weak statistical significance and coefficient sizes are small. Negative and statistically significant effects are observed on teacher experience, absenteeism for observing funerals and official business and the condition of a teacher's home, which proxies for teacher wealth.

As expected, the results for the full sample obscure the separate data generating processes that exist for the two systems of schools. In the more privileged quartile of schools, with higher average student achievement and moderate teacher strike activity, there is no evidence of negative average impacts of teacher strike activity on student achievement (see Table 4Table 4). The student fixed effects estimate for striking at least one day is actually positive and significant in the first two specifications. After controlling for teacher ability, as reflected in teacher test scores, the average effect size of a teacher striking reduces to positive 0.024 and becomes statistically insignificant.

The observed impact of teacher strike action on student learning in non-privileged schools is markedly different. In these schools, where teacher unions are strongly represented and more militant, strike activity appears to be detrimental to learning. In the fixed effects estimations for students in Table 5, the average effect of striking on student test scores is consistently negative and significant. In the first specification, with no other teacher controls, the fixed effect strike estimate is about 7.8 per cent of a standard deviation in learning. Controlling for teacher characteristics likely to be

predetermined before joining a union reduces the estimate slightly to 6.5 per cent, but adding the remaining teacher controls increases the negative effect to ten per cent in specification four. In other words after controlling for teacher ability, a student's achievement is ten per cent of a standard deviation lower in a subject taught by a striking teacher compared with their achievement in a subject taught by a non-striking teacher.

To test the robustness of this result to the split of the sample by socio-economic status of the student's school, fixed effects regressions using the full specification of variables were run for different SES sample splits. Results appear to be robust to the school socio-economic sample split with effect sizes concentrated at ten per cent of a standard deviation (see Figure 3 for a plot of teacher strike participation effects for different sample splits by schools SES).

Admittedly, the sensitivity of the results to the inclusion of controls in the four specifications raises questions about the direction of omitted variable bias in fixed effects estimations. However, the OLS estimates of average strike effects in the poorest three quarters of schools are consistently upwardly biased, being small in size, positive and statistically insignificant when contrasted against fixed effects estimates.

At face value, the fixed effects results indicate that in the majority of South Africa's primary schools, the 2007 teacher strikes had negative consequences for student learning at the grade six level. Using standard rules of thumb for interpreting effect sizes, ten per cent of a standard deviation in student learning would be considered a small effect (Cohen, 1988). Effect sizes, however, are more appropriately interpreted by comparing them against empirical benchmarks appropriate to the context investigated (Hill et al., 2008). For example, the average strike effect size on learning could be compared to the effects of other teacher characteristics or school inputs malleable to policy-making decisions. Alternatively, one could consider the strike effect in relation to anticipated growth in learning during a school year or identify its implications for widening or reducing learning gaps between the poorest and wealthiest students.

Following these suggestions, the average absolute value of the strike effect in the poorest three quarters of schools is roughly comparable to the coefficient on having a teaching degree as opposed to no degree. In these schools, strike action has the potential to counteract learning benefits associated with employing teachers with higher level university skills.

Table 3: OLS and student fixed effects estimations of student achievement, students in all schools

Teacher controls:	1) Only teacher strike activity		2) Add: teacher variables predetermined before unionization		3) Add: teacher variables determined after unionization		4) Add: teacher test score (limited sample)	
	OLS	Student FE	OLS	Student FE	OLS	Student FE	OLS	Student FE
Teacher strike participation (0/1 indicator)^	0.0174	-0.0425**	0.0345	-0.0223	0.0169	-0.0308	-0.0132	-0.0321
	(0.039)	(0.016)	(0.038)	(0.016)	(0.045)	(0.019)	(0.048)	(0.022)
Teacher has degree^			0.0698**	0.0631***	0.0763**	0.0687***	0.0601*	0.0588***
			(0.031)	(0.013)	(0.031)	(0.012)	(0.032)	(0.013)
Teacher is male^			-0.0444	-0.0386**	-0.0307	-0.0350**	-0.0349	-0.0315**
			(0.030)	(0.012)	(0.028)	(0.012)	(0.029)	(0.013)
Teacher pre-service training: <=1 year^			0.0795	0.0089	0.0602	0.0129	0.0245	0.0061
			(0.079)	(0.030)	(0.076)	(0.030)	(0.082)	(0.033)
Teacher pre-service training: 2 years^			0.0245	0.1728***	0.0209	0.1968***	0.0361	0.2001***
			(0.056)	(0.025)	(0.057)	(0.025)	(0.057)	(0.026)
Teacher pre-service training: 3 years^			0.0664**	0.0828***	0.0603*	0.0799***	0.0550*	0.0808***
			(0.030)	(0.013)	(0.031)	(0.013)	(0.033)	(0.014)
Teacher's age			-0.0544***	-0.011	-0.0503**	-0.0054	-0.0481**	-0.0085
			(0.014)	(0.007)	(0.015)	(0.007)	(0.016)	(0.007)
Teacher's age squared			0.0006***	0.0001	0.0006***	0.0001	0.0006***	0.0001
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Teacher's experience					-0.0035	-0.0026*	-0.0059*	-0.0030*
					(0.004)	(0.002)	(0.004)	(0.002)
Days absent: own illness					0.0014	0.001	0.0024	0.0014*
					(0.003)	(0.001)	(0.003)	(0.001)
Days absent: funerals					0.0044	-0.0050**	0.0008	-0.0055**
					(0.007)	(0.002)	(0.006)	(0.002)
Days absent: official business					-0.0056*	-0.0108***	-0.0066*	-0.0117***
					(0.003)	(0.002)	(0.003)	(0.002)
Hours spent on lesson preparation & marking					-0.0011	0.0016*	-0.0007	0.0016*
					(0.002)	(0.001)	(0.002)	(0.001)

Table 3 Continued…	1) Only strike activity		2) Add: teacher variables predetermined before unionization		3) Add: teacher variables determined after unionization		4) Add: teacher test score (limited sample)	
Own home in poor condition/need of repair^					-0.0518	-0.0525***	-0.0261	-0.0319**
					(0.034)	(0.013)	(0.036)	(0.014)
Gets monthly teaching advice from principal^					0.0567*	0.0600***	0.0736**	0.0760***
					(0.029)	(0.013)	(0.030)	(0.014)
Enough sitting places in classroom for students^					0.0622	0.0383**	0.0548	0.0296
					(0.040)	(0.018)	(0.040)	(0.019)
Teacher gets parents to sign student work^					0.0495	-0.0264**	0.0704**	-0.0072
					(0.035)	(0.013)	(0.036)	(0.014)
Teacher's teaching supplies Index					0.0681	0.1145**	0.0553	0.0127
					(0.111)	(0.036)	(0.126)	(0.043)
Teacher wrote subject specific test^					-0.0093	0.0509**		
					(0.064)	(0.024)		
Teachers' test score (std)							0.0779***	0.0532***
							(0.015)	(0.007)
Subject Dummy: Reading^	-0.0029	-0.0039	-0.0132	-0.0116	-0.0121	-0.0099	-0.0137	-0.0150*
	(0.017)	(0.008)	(0.018)	(0.008)	(0.018)	(0.008)	(0.018)	(0.009)
Subject Dummy: Health^	0.0485*	0.0472***	0.0304	0.0306**	0.0274	0.0297**	0.0268	0.0256**
	(0.029)	(0.011)	(0.031)	(0.012)	(0.030)	(0.012)	(0.030)	(0.012)
Constant	-0.6789	-0.0137	0.4040	0.1746	0.3722	0.1544	0.2882	-0.0919
	(0.112)	(0.014)	(0.333)	(0.148)	(0.349)	(0.149)	(0.363)	(0.154)
Student characteristics	Yes	No	Yes	No	Yes	No	Yes	No
School characteristics	Yes	No	Yes	No	Yes	No	Yes	No
Province dummies	Yes	No	Yes	No	Yes	No	Yes	No
R-squared	0.428	-	0.432	-	0.436	-	0.442	-
Within R-squared	-	0.003	-	0.019	-	0.021	-	0.029
F-stat (p-value)	52 (0.000)	11 (0.000)	50 (0.000)	13	48 (0.000)	12 (0.000)	53 (0.000)	16 (0.000)
Subject-student obs. (N)	24 701	24 701	24 701	24 701	24 701	24 701	22 382	22 382
Number of clusters	-	8 254	-	8 254	-	8 254	-	8 144
Number of schools	364	364	364	364	364	364	361	361

Notes: OLS controls include additional student, school characteristics and provincial dummies. Standard errors were corrected for clustering of errors between subjects within a student (student id as the clustering variable) and probability sampling weights included. Statistically significant ***1% level, **5% level,*10% level. Standard errors in parentheses.^Dichotomous 0/1 variable.

Table 4: OLS and student fixed effects estimations of student achievement, students in wealthiest 25% of schools

Teacher Controls:	**1) Only strike activity**		**2) Add: teacher variables predetermined before unionization**		**3) Add: teacher variables determined after unionization**		**4) Add: teacher test score (limited sample)**	
	OLS	**Student FE**	**OLS**	**Student FE**	**OLS**	**Student FE**	**OLS**	**Student FE**
Teacher strike participation^	0.0304	0.0667**	0.0456	0.0709**	0.0412	0.0383	0.0174	0.0243
	(0.050)	(0.029)	(0.049)	(0.029)	(0.045)	(0.031)	(0.046)	(0.034)
Teacher has degree^			0.0484	-0.0035	0.0013	-0.0355	-0.0491	-0.0730**
			(0.055)	(0.029)	(0.052)	(0.032)	(0.050)	(0.035)
Teacher is male^			0.0321	0.0332	0.0295	0.0056	0.0202	0.0305
			(0.048)	(0.026)	(0.049)	(0.027)	(0.043)	(0.030)
Teacher pre-service training: <=1 year^			-0.0476	-0.015	-0.0057	0.0027	-0.0256	0.0336
			(0.098)	(0.044)	(0.079)	(0.043)	(0.081)	(0.051)
Teacher pre-service training: 2 years^			0.0687	0.3140***	0.2335**	0.3531***	0.2154**	0.3277***
			(0.108)	(0.067)	(0.103)	(0.069)	(0.104)	(0.068)
Teacher pre-service training: 3 years^			0.0159	0.1460***	0.0429	0.1382***	0.0717	0.1396***
			(0.060)	(0.032)	(0.051)	(0.031)	(0.046)	(0.033)
Teacher's age			-0.0293*	-0.0155	-0.0292	-0.01	-0.0431**	-0.0212*
			(0.017)	(0.010)	(0.018)	(0.011)	(0.019)	(0.011)
Teacher's age squared			0.0003	0.0001	0.0004*	0.0001	0.0005**	0.0002*
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Teacher's experience					-0.0064	-0.0035	-0.0041	-0.001
					(0.006)	(0.003)	(0.005)	(0.003)
Days absent: own illness^					-0.0028	-0.0007	-0.0009	0.0088*
					(0.006)	(0.004)	(0.006)	(0.005)
Days absent: funerals^					0.0378**	0.0169	0.0353**	0.0139
					(0.018)	(0.011)	(0.016)	(0.011)
Days absent: official business^					-0.0033	0.0016	-0.0053	-0.0099
					(0.011)	(0.007)	(0.009)	(0.007)
Hours spent lesson preparation & marking					0.0096**	0.0035	0.0105**	0.0045*
					(0.004)	(0.003)	(0.004)	(0.003)

Table 4 Continued…	**1) Only strike activity**		**2) Add: teacher variables predetermined before unionization**		**3) Add: teacher variables determined after unionization**		**4) Add: teacher test score (limited sample)**	
Own home in poor condition/need of repair^					-0.1148	-0.0624	0.0037	0.0522
					(0.084)	(0.046)	(0.077)	(0.048)
Gets monthly teaching advice from principal^					0.2006***	0.0854**	0.2423***	0.1439***
					(0.048)	(0.033)	(0.050)	(0.035)
Enough sitting places in classroom for students^					-0.058	0.1138**	-0.0228	0.0936**
					(0.059)	(0.042)	(0.054)	(0.043)
Teacher gets parents to sign student work^					-0.0566	-0.1026**	-0.0264	-0.0215
					(0.054)	(0.033)	(0.053)	(0.035)
Teacher's teaching supplies Index					0.2345**	0.2626***	0.2108*	0.0116
					(0.093)	(0.067)	(0.111)	(0.077)
Teacher wrote subject specific test^					-0.1556*	-0.0916*		
					(0.079)	(0.050)		
Teachers' test score (std)							0.0895***	0.0905***
							(0.021)	(0.014)
Subject Dummy: Reading^	0.1217***	0.1237***	0.1171***	0.1116***	0.1174**	0.1164***	0.1302**	0.1237***
	(0.036)	(0.018)	(0.034)	(0.019)	(0.039)	(0.019)	(0.040)	(0.020)
Subject Dummy: Health^	-0.1516**	-0.1506***	-0.1677**	-0.1724***	-0.1639**	-0.1664***	-0.1539**	-0.1585***
	(0.058)	(0.025)	(0.058)	(0.025)	(0.061)	(0.026)	(0.062)	(0.026)
Constant	-1.3880*	0.9054***	-0.8008	1.2679***	-0.8419	1.2626***	-0.9045	0.9673***
	(0.759)	(0.021)	(0.851)	(0.220)	(0.824)	(0.225)	(0.835)	(0.244)
Student characteristics	Yes	No	Yes	No	Yes	No	Yes	No
School characteristics	Yes	No	Yes	No	Yes	No	Yes	No
Province dummies	Yes	No	Yes	No	Yes	No	Yes	No
R-squared	0.375	-	0.380	-	0.392	-	0.395	-
Within R-squared	-	0.051	-	0.076	-	0.081	-	0.103
F-stat (p-value)	68 (0.000)	55 (0.000)	60.55 (0.000)	25 (0.000)	52 (0.000)	14 (0.000)	48 (0.000)	15 (0.000)
Subject-student obs. (N)	5 587	5 587	5 587	5 587	5 587	5 587	4 936	4 936
Number of clusters	84	1 868	84	1 868	84	1 868	83	1 825

Notes: OLS controls include additional student, school characteristics and provincial dummies. Standard errors were corrected for clustering of errors between subjects within a student (student id as the clustering variable) and probability sampling weights included. Statistically significant ***1% level, **5% level, *10% level. Standard errors in parentheses. ^Dichotomous 0/1 variable

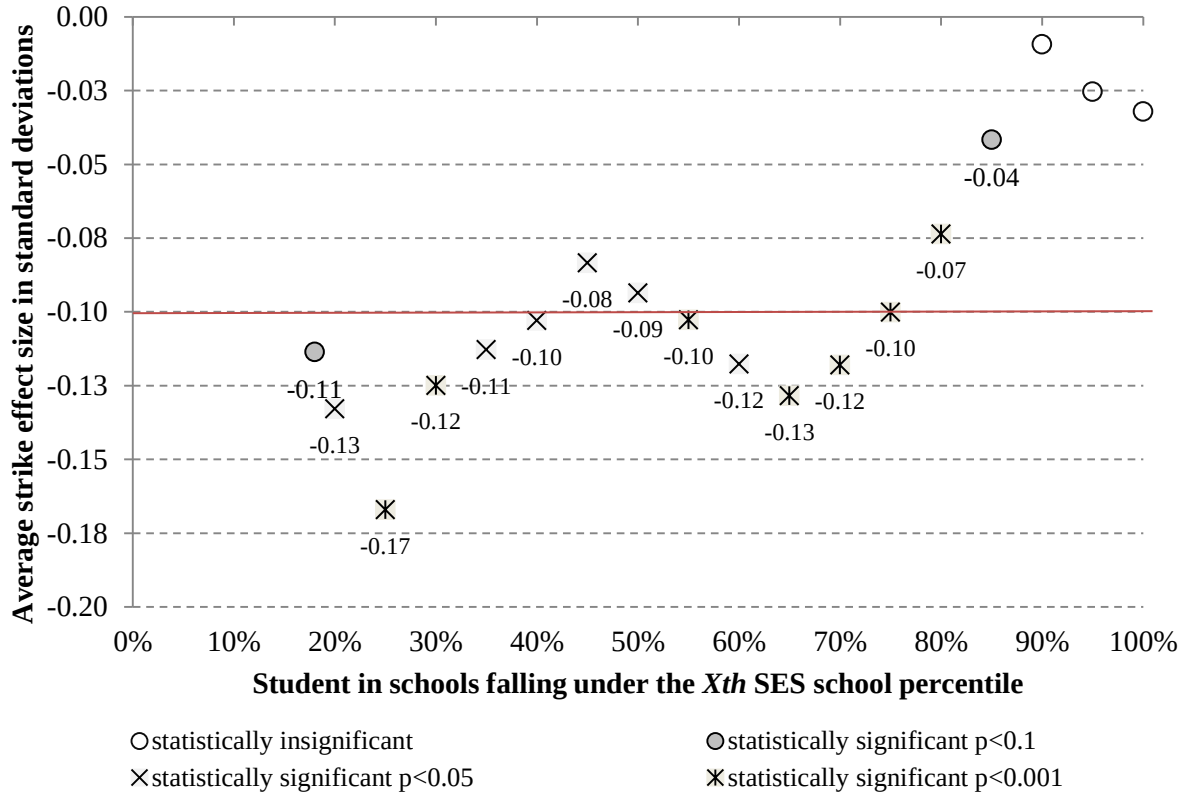
Table 5: OLS and student fixed effects estimations of student achievement, students in poorest 75% of schools

Teacher Controls:	1) Only strike activity		2) Add: teacher variables predetermined before unionization		3) Add: teacher variables determined after unionization		4) Add: teacher test score (limited sample)	
	OLS	Student FE	OLS	Student FE	OLS	Student FE	OLS	Student FE
Teacher strike participation^	0.0289	-0.0783***	0.0378	-0.0651***	0.0257	-0.1025***	0.0023	-0.1001***
	(0.046)	(0.018)	(0.045)	(0.018)	(0.056)	(0.023)	(0.065)	(0.027)
Teacher has degree^			0.0646*	0.0890***	0.0798**	0.1038***	0.0804**	0.0994***
			(0.035)	(0.014)	(0.033)	(0.014)	(0.034)	(0.015)
Teacher is male^			-0.0436	-0.0323**	-0.0269	-0.0301**	-0.0326	-0.0192
			(0.035)	(0.013)	(0.032)	(0.013)	(0.033)	(0.014)
Teacher pre-service training: <=1 year^			0.1196	0.0082	0.0798	-0.0016	0.0653	-0.0109
			(0.097)	(0.039)	(0.097)	(0.039)	(0.100)	(0.040)
Teacher pre-service training: 2 years^			0.0326	0.1488***	0.0361	0.1530***	0.0452	0.1503***
			(0.058)	(0.027)	(0.056)	(0.027)	(0.057)	(0.028)
Teacher pre-service training: 3 years^			0.0761**	0.0583***	0.0661*	0.0456***	0.0566	0.0360**
			(0.032)	(0.013)	(0.034)	(0.014)	(0.038)	(0.015)
Teacher's age			-0.0492**	0.0133	-0.0450*	0.0178*	-0.0377	0.0292**
			(0.024)	(0.009)	(0.024)	(0.010)	(0.025)	(0.010)
Teacher's age squared			0.0006**	-0.0002*	0.0006**	-0.0002**	0.0005*	-0.0003**
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Teacher's experience					-0.0061	-0.0030*	-0.0084**	-0.0035**
					(0.004)	(0.002)	(0.004)	(0.002)
Days absent: own illness					0.0019	0.0016**	0.003	0.0017**
					(0.002)	(0.001)	(0.002)	(0.001)
Days absent: funerals					0.0021	-0.0051**	-0.0005	-0.0055**
					(0.006)	(0.002)	(0.006)	(0.002)
Days absent: official business					-0.0056*	-0.0100***	-0.0061*	-0.0103***
					(0.003)	(0.002)	(0.003)	(0.002)
Hours spent on lesson preparation & marking					-0.0042*	0.0014	-0.0034	0.0015*
					(0.002)	(0.001)	(0.002)	(0.001)

Table 5 Continued…	**1) Only strike activity**		**2) Add: teacher variables predetermined before unionization**		**3) Add: teacher variables determined after unionization**		**4) Add: teacher test score (limited sample)**	
Own home in poor condition/need of repair^					-0.0511	-0.0307**	-0.03	-0.0260*
					(0.035)	(0.014)	(0.037)	(0.014)
Gets monthly teaching advice from principal^					0.0357	0.0634***	0.0476	0.0735***
					(0.032)	(0.014)	(0.033)	(0.015)
Enough sitting places in classroom for students^					0.0536	0.027	0.0458	0.0181
					(0.042)	(0.019)	(0.043)	(0.021)
Teacher gets parents to sign student work^					0.0581	0.0167	0.0735*	0.0178
					(0.040)	(0.014)	(0.040)	(0.015)
Teacher's teaching supplies Index					0.0351	0.1333**	0.0094	0.0343
					(0.130)	(0.044)	(0.142)	(0.050)
Teacher wrote subject specific test^					-0.0121	0.0876**		
					(0.073)	(0.027)		
Teachers' test score (std)							0.0460**	0.0134*
							(0.020)	(0.008)
Subject Dummy: Reading^	-0.0414**	-0.0413***	-0.0479**	-0.0441***	-0.0503**	-0.0443***	-0.0515**	-0.0520***
	(0.019)	(0.009)	(0.020)	(0.009)	(0.020)	(0.009)	(0.020)	(0.010)
Subject Dummy: Health^	0.1111***	0.1076***	0.0907**	0.0978***	0.0805**	0.0963***	0.0803**	0.0889***
	(0.033)	(0.013)	(0.036)	(0.013)	(0.035)	(0.013)	(0.035)	(0.013)
Constant	-0.7628***	-0.2876***	0.1915	-0.5599**	0.1552	-0.5357**	0.1263	-0.8419***
	(0.115)	(0.017)	(0.518)	(0.200)	(0.515)	(0.202)	(0.529)	(0.208)
Student characteristics	Yes	No	Yes	No	Yes	No	Yes	No
School characteristics	Yes	No	Yes	No	Yes	No	Yes	No
Province dummies	Yes	No	Yes	No	Yes	No	Yes	No
R-squared	0.156	-	0.167	-	0.168	-	0.170	-
Within R-squared	-	0.022	-	0.038	-	0.042	-	0.050
F-stat (p-value)	21 (0.000)	67 (0.000)	18 (0.000)	26 (0.000)	18 (0.000)	17 (0.000)	18 (0.000)	18 (0.000)
Subject-student obs. (N)	19 114	19 114	19 114	19 114	19 114	19 114	17 446	17 446
Number of clusters	280	6 386	280	6 386	280	6 386	278	6 319

Notes: OLS controls include student, school characteristics and provincial dummies. Standard errors were corrected for clustering of errors between subjects within a student (student id as the clustering variable) and probability sampling weights included. Statistically significant ***1% level, **5% level, *10% level. Standard errors in parentheses. ^Dichotomous 0/1 variable.

Figure 3: Strike participation effects on student achievement using different sample splits of school SES



The magnitude of the strike effect is particularly sobering when interpreted in relation to anticipated learning in a year. The National School Effectiveness Study in South Africa suggests that between grade three and grade five students learn approximately 40 per cent of a standard deviation each year.[15] Using this benchmark, an average strike effect of ten per cent of a standard deviation implies that students in the poorest three quarters of schools lost the equivalent of a quarter of a year's learning in 2007 due to strike action. This may appear very high when on average self-reported days that a teacher strikes in these schools was thirteen days representing only seven per cent of about 187 operational school days that year.[16] There are two possible explanations for this mismatch. The strike effect may also be capturing an aspect of teacher quality where teachers who strike in the poorest schools are of lower quality. Alternatively, strike activity in these schools may have had further negative spill-over effects. In the month of June when the 2007 public sector strike occurred, most schools write mid-year tests and then marking of tests and writing of school reports is often executed

[15] This is consistent with literature on learning in the United States, where between the third and fifth grade students are expected to learn between 36 and 40 per cent of standard deviation for reading and 50 per cent of standard deviation in mathematics (Hill et al., 2008).

[16] There were 196 official school days in 2007. However subtracted from this *de facto* total is the average number of reported days schools were closed due to disruptions as reported by principals in the poorest 75 per cent of schools at nine days. It is likely, however, that 187 remains a considerable overestimation of total teaching days. On average schools may have closed for more days than reported by school principals, closing early or suspending teaching during periods of testing and marking.

during the winter break. If tests were postponed into the second half of the year, test revision may be prioritised over teaching of new curriculum before tests recommence. Furthermore, teaching time and lesson preparation may be reallocated for postponed marking and report writing.

With respect to reducing large inequalities in educational quality, as reflected in large achievement gaps between poor and wealthier students, the strike impacts are further contextualised. Subtracting average test scores in health, reading and numeracy for students in the wealthiest 25 per cent of schools from the poorest 75 per cent of schools, and dividing by the standard deviation in test scores for the total sample yields a performance gap of 1.3 standard deviations. In the absence of teacher strikes in 2007, this achievement gap could have been reduced by nearly 8 per cent (see Table 6).

Table 6: Achievement gap in learning across students in poorer and wealthier schools, SACMEQ III 2007

	Mean	**Standard Deviation**	**N**
Students in wealthiest 25% of schools	600.29	101.54	6 748
Students in poorest 75% of schools	462.97	81.67	20 427
Total	**497.54**	**105.53**	**27 175**
Achievement gap (in standard deviations)		-1.301	
Strike effect size in poorest 75% of schools (in standard deviations)		-0.1010	
% reduction in performance gap in the absence of strike action		7.76%	

Source: SACMEQ III. **Notes:** The achievement gap is calculated as the difference in mean learning between the poorest 75% of schools and wealthiest 25% of schools, divided by the standard deviation in scores for the total sample. Mean student scores are calculated using numeracy, reading and health scores used in the estimations. Calculations account for probability weights in sampling design. Sample sizes reflect student-subject observations.

The potential repercussions of strike action for augmenting educational inequality is also observed comparing fixed effects estimates for samples of marginalised versus less marginalised students. Strike impacts are anticipated to most negatively affect students that are poorest and the weakest academically. This has been implied in the different strike effects observed across the poorest and wealthiest schools. It is further confirmed when running estimates on samples of rural versus urban schools and by quartiles of student achievement. Using the full set of teacher controls, and specifically teacher test scores (i.e. specification four), average strike effects for each sample are summarized in Table 7. Students in rural schools are adversely affected by teacher strikes compared with their urban counterparts. A negative strike effect, as large as 17 per cent of a standard deviation, is observed for students in rural schools, whereas no significant effects are identified for students in urban schools. As expected, negative strike effect sizes increase at lower levels of student achievement. Negative strike effects for students that are in the bottom three quartiles of student achievement are observed while no effect is observed for the top performing quartile of students. This mirrors the results obtained when disaggregating the sample by quartiles of school socio-economic status.

Table 7: Teacher strike participation effects on student achievement for marginalised and non-marginalised samples of students, SACMEQ III 2007

Sample:	By urban/rural status of school		By average academic achievement of students in three subject tests			
	Rural	Urban	quartile 1	quartile 2	quartile 3	quartile 4
Dummy: Teacher strike participation	-0.1649***	0.0267	-0.1067*	-0.0804*	-0.0710*	0.0276
	(0.044)	(0.024)	(0.055)	(0.044)	(0.039)	(0.036)
Within R-squared	0.0779	0.0378	0.0173	0.0826	0.0703	0.0837
F-stat (p-value)	20 (0.000)	11 (0.000)	2.4 (0.0004)	15 (0.000)	8.3 (0.000)	15 (0.000)
Subject-student obs. (N)	10 290	12 092	5 737	5 820	5 689	5 136
Number of clusters	3 700	4 500	2 100	2 100	2 100	1 900

Notes: See Table 5, specification 4 for full list of controls. Constant included but not shown. Standard errors were corrected for clustering of errors between subjects within a student (student id as the clustering variable) and probability sampling weights accounted for. Samples are not limited to the 75 per cent poorest schools but all schools are considered in the different samples. For example urban schools may include schools in the top SES quartile. Statistically significant ***1% level, **5% level, *10% level. Standard errors in parentheses.

8. Comparing effects: Strike vs. other teacher absence

The teacher strike absenteeism effect can also be compared to absenteeism effects due to other reasons of absence. OLS and fixed effects estimations are re-run using a full set of teacher controls but replacing the 0/1 indicator variable for strike action with a continuous variable for days absent due to teacher strikes. Consistent with the previous estimations, days absent for own illness, official business and funerals are included as teacher controls.

Table 8 summarises effect sizes on the four different variables for days absent for the full sample of schools, the poorest 75 per cent of schools and the wealthiest 25 per cent of schools. In the poorest schools, student fixed effects shows that a student's achievement in a subject will decrease by 0.49 per cent of a standard deviation if their teacher in that subject is absent for one additional day compared to another subject teacher's strike absence.[17] Comparatively, one additional day absent for strike action has roughly a similar negative effect as absence for attending funerals. A surprising result is the positive and significant coefficient on days absent for own illness at 0.15.[18]

An interesting result in relation to the strike effect is the larger negative effect on days absent for 'official business' in the poorest three quarters of schools. Here an additional day of absence for 'official business' is twice as detrimental to learning as an additional day of absence for strike activity. It is arguable that the coefficient on days absent for 'official business' may be capturing an effect of union membership on student learning. Subsumed within the category 'official business',

[17] Following Clotfelter, Ladd and Vigdor (2009), days absent were included in linear form in the estimation but non-linear functional forms may be a more suitable specification.

[18] Compare this with negative effects of sick leave observed in the United States for example, where effect sizes related to one additional day of absence for illness range between -0.003 and -0.001 of a standard deviation on student test scores in OLS and teacher fixed effects estimations using panel data (Clotfelter, Ladd and Vigdor, 2009).

reasons for absence may likely include attending union related meetings or activities. This is supported by findings of a research project published by the Human Sciences Research Council (HSRC) investigating teacher absence in South African public schools. Their survey of teachers identified that second to training and curriculum workshops organised by the Department of Education, the most common reason for official business leave was union related (Reddy et al., 2010: 77). This is expected where provision is made in South African labour law and by the Department of Education for educator paid leave in fulfilling certain union related activities.[19] However, the negative effect on 'official business' absence may also reflect that training and curriculum workshops scheduled during formal teaching time are having unintended negative consequences for learning. This supports recommendations made in the HSRC report and policy brief by Reddy et al (2010) that provincial directorates who request teachers and principals to attend meetings should co-ordinate these workshops outside the formal school day.

[19] Teachers who are members but neither office bearers nor shop stewards of recognised employee organisations (i.e. unions) are entitled to about eight *hours* absence in a year for membership related activities, while those who are office bearers or shop stewards are entitled to twelve days paid leave per year for activities related to their union position (Reddy et al., 2010: 33).

Table 8: OLS and student fixed effect estimations of student achievement using continuous variable for strike days absent, SACMEQ III 2007

	All schools			Poorest 75%			Wealthiest 25%		
Number of days absent for…	**OLS**	**Student FE**	***Mean of variable for estimation sample***	**OLS**	**Student FE**	***Mean of variable for estimation sample***	**OLS**	**Student FE**	***Mean of variable for estimation sample***
Strike	-0.0059**	-0.0043***	*12.296*	-0.0048	-0.0049***	*14.667*	0.0019	0.0076**	*4.484*
	(0.003)	(0.001)	*(0.407)*	(0.003)	(0.001)	*(0.371)*	(0.004)	(0.004)	*(0.943)*
Own illness	0.0025	0.0014*	*2.904*	0.0031	0.0015*	*3.031*	-0.001	0.0068	*2.486*
	(0.003)	(0.001)	*(0.323)*	(0.002)	(0.001)	*(0.412)*	(0.006)	(0.005)	*(0.320)*
Funeral	0.0014	-0.0052**	*0.857*	0.0004	-0.0056**	*0.963*	0.0360**	0.0151	*0.506*
	(0.006)	(0.002)	*(0.078)*	(0.006)	(0.002)	*(0.091)*	(0.016)	(0.011)	*(0.135)*
Official business	-0.0068**	-0.0117***	*1.755*	-0.0062**	-0.0101***	*2.042*	-0.0047	-0.0074	*0.807*
	(0.003)	(0.002)	*(0.153)*	(0.003)	(0.002)	*(0.186)*	(0.010)	(0.007)	*(0.193)*
R-squared	0.443	-		0.172	-		0.395	-	
Within R-squared	-	0.030		-	0.050		-	0.104	
F-stat	54.637	16.165		18.153	18.018		.	15.234	
N	22 382	22 382		17 446	17 446		4 936	4 936	
Number of clusters	-	8 144		-	6 319		-	1 825	

Notes: See Table 5, specification 4 for a full list of controls. Constant included in estimation but not shown. Standard errors were corrected for clustering of errors between subjects within a student (student id as the clustering variable) and probability sampling weights included. Statistically significant ***1% level, **5% level, *10% level. Standard errors in parentheses.

9. Omitted Variable Bias

The fixed effects estimates have shown significant, negative effects of strike action on learning in the poorest three quartiles of schools with implications for aggravating inequality in the provision of education. However, it is not possible to rule out that fixed effects estimates are compromised by omitted variable bias. The student fixed effects estimations control for all school characteristics and unobserved student family background but they have not eliminated heterogeneity in teachers' unobserved characteristics. In addressing this remaining issue, instrumental variable estimation is typically used to identify variation in the treatment that is exogenously related to the outcome, student learning. However, there is no available instrument for strike action in the SACMEQ III data that informs a teacher's decision to strike but is uncorrelated with student learning.

Acknowledging the limitations of social research to make causal inferences from cross-sectional data; Altonji, Taber and Elder (2005) recently developed a technique to draw conclusions about potential omitted variable bias. Their method proceeds by carefully examining the selection on the observable characteristics as a guide to selection on unobservables.

Given that the independence of unobservables assumption in OLS (and in fixed effects estimation) is likely to be violated, Altonji et al's approach identifies how large the bias from selection on unobservables would be if that selection is in the same order as the selection on observables. The equality of selection on observables and unobservables is reflected in the following condition,

$$\frac{Cov(\upsilon,\ strike)}{Var(\upsilon)} = \frac{Cov(\gamma T, strike)}{Var(\gamma T)} \tag{5}$$

where the error term, υ, reflects teacher unobservables. The relationship between strike participation and the index of observed teacher characteristics (normalized by the size of the variance in that index) is equated to the relationship between strike participation and the unobservable part that determines student achievement. Under the equality of selection assumption, it is possible to estimate the size of the asymptotic bias. If υ and T are orthogonal then $Cov(\upsilon, strike)$ is equivalent to $Cov(\upsilon, \widetilde{strike})$, where the tildes over the strike variable denote the residuals from a regression of that variable on teacher characteristics. The asymptotic bias in the estimate of interest is reflected as follows:

$$plim\ \hat{\theta}\ \approx\ \theta + \frac{Cov(\widetilde{strike}, \upsilon)}{Var(\widetilde{strike})} = \frac{Cov(strike, \upsilon)}{Var(\widetilde{strike})} \tag{6}$$

Substituting from equation 5, the bias in equation 6 can be written as:

$$\frac{Cov(strike, v)}{Cov(\widetilde{strike})} = \frac{Cov(\gamma T, strike)}{Var(\gamma T)} \frac{Var(v)}{Var(\widetilde{strike})} \quad (7)$$

Calculating this bias requires a three step process (Freier and Storck, 2012). The first step is to estimate an OLS (or fixed effects) model of student achievement on all explanatory variables except the treatment, i.e. $strike$, which is excluded from the regression. From this estimation it is possible to generate the first component necessary for the bias calculation, namely $var(v)$ – the variance in student achievement that cannot be explained by the observed control variables. This is simply the variance of the residual of the equation. This estimation is also used to get the predicted index of observable teacher characteristics, $\gamma\hat{T}$. In the second step, the predicted index of observables from the previous estimation, $\gamma\hat{T}$, is regressed on the treatment variable, $strike$. The coefficient on the predicted index in that regression gives the term, $\frac{Cov(\gamma T, strike)}{Var(\gamma T)}$. The third step is to generate the last component $Var(\widetilde{strike})$ needed to calculate the bias. This is the variance of the residual from a regression of the treatment on all teacher characteristics, T.

. Following equation 7, the three components are used to calculate what the implied bias would be under the assumption of equality of selection on unobservables and observables. The calculation is applied in relation to estimates of strike participation effects in the poorest 75 per cent of schools, where significant negative strike effects were observed (recall Table 5). In addition to calculating the implied bias, Altonji et al also recommend calculating the ratio of the main OLS treatment effect divided by the implied bias. This provides a measure of how strong the selection on unobservables would have to be, relative to selection on observables, to explain the entire treatment effect. Table 9 identifies the bias and ratio as well as summarising the relevant strike effects from the OLS and fixed effects estimations in Table 5

Both the direction and size of the implied bias is important for interpretation. In Table 9 the direction of the implied bias is negative and its size is multiple times larger than the observed strike effect. Together this suggests that the estimated negative strike effect in the poorest 75 per cent of schools is overstated, where omitted variable bias could potentially account for all of the observed strike effect. It is noticeable that the implied bias reduces in size after adding more teacher controls; nevertheless it remains substantially larger than the strike effect. After controlling for teacher ability as reflected in teacher test scores, the calculated ratio is 0.23 in specification four. In other words, selection on unobservables would only have to be about 23 per cent stronger than selection on observables to explain away the entire strike effect. The ability to make causal inferences therefore is compromised due to omitted variable bias.

Table 9: Summary of teacher strike participation effects on student achievement in OLS and student fixed estimations for the poorest 75% of schools, SACMEQ III 2007

	1) Only strike activity		2) Add: teacher var. predetermined before unionization		3) Add: teacher var. non-predetermined before unionization		4) Add: teacher test score (limited sample)	
	OLS	**Student FE**	**OLS**	**Student FE**	**OLS**	**Student FE**	**OLS**	**Student FE**
Dummy: Teacher strike participation	0.0289	-0.0783***	0.0378	-0.0651***	0.0257	-0.1025***	0.0023	-0.1001***
	(0.046)	(0.018)	(0.045)	(0.018)	(0.056)	(0.023)	(0.065)	(0.027)
Subject Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Student characteristics	Yes	No	Yes	No	Yes	No	Yes	No
School characteristics	Yes	No	Yes	No	Yes	No	Yes	No
Province dummies	Yes	No	Yes	No	Yes	No	Yes	No
R-squared	0.156	-	0.167	-	0.168	-	0.170	-
Within R-squared	-	0.022	-	0.038	-	0.042	-	0.050
F-stat	21.264	67.242	18.316	17.623	18.090	16.760	17.705	18.082
Subject-student obs. (N)	19 114	19 114	19 114	19 114	19 114	19 114	17 446	17 446
Number of clusters	280	6 386	280	6 386	280	6 386	278	6 319
Estimated Bias (Eq. 7)		-		-1.535		-0.5723		-0.430
Ratio[a]		-		0.051		0.179		0.233

Notes: See Table 5 for a full list of control variables used. Standard errors were corrected for clustering of errors between subjects within a student (student id as the clustering variable) and probability sampling weights included. Statistically significant at ***1% level, **5% level, *10% level. Standard errors are in parentheses. Constant included by not shown in these results. [a]This is the ratio of the coefficient on the strike variable and the estimated bias. The bias is only calculated for the estimations where strike effects were significant and where additional controls are included for teacher characteristics.

Altonji et al, however, caution against inferring too much from the implied bias given the rigid assumptions on which their technique is based.[20] Assuming that selection on unobservables is the same as selection on observables, this bias is likely to reflect an upper bound of the influence of unobservables and the actual degree is likely to fall short of that (Freier and Storck, 2012). Furthermore, one may also question the assumption that selection into strike participation on the basis of observed teacher characteristics is the same as selection into strike participation based on unobserved teacher characteristics.

The findings of Kingdon and Teal (2010) offer a discussion point in this regard if we assume that the average effect for teacher strike participation in South Africa offers a proxy for a teacher union effect on learning. They identify a negative teacher union membership effect on student learning in India using student fixed effects estimation. In their case, causal inference is supported through a *positive* Altonji bias; and the positive sign on the bias is due to a positive relationship between observed teacher characteristics and union membership. By contrast, an inverse relationship between observed

[20] Drawing conclusions about selection on the unobservables from selection on the observables requires that the observables are large in number, have considerable explanatory power and are a random selection of all possible factors influencing the outcome. Although a large number of variables have been included, the explanatory power of the fixed effect estimations here is low with very little within variation, largely because differences in student achievement occur across students rather than within individual students.

teacher characteristics and strike participation in South Africa drives the implied negative bias. The possibility remains that unobservable teacher characteristics could be positively correlated with strike participation in South Africa, raising questions about the direction of omitted variable bias.

10. Conclusion

This research finds heterogeneous impacts on student achievement of teacher participation in the 2007 public service strike. In the privileged upper quartile of schools, where strike participation is less common and the duration of strike action limited, little to no negative teacher strike effects were identified. By contrast, in the bottom three quartiles of schools where participation in the strike was widespread, militant and typically long in duration, strike activity appears to be detrimental to learning. Here a student's performance in a subject taught by a striking teacher was about ten per cent of a standard deviation lower than his or her performance in a subject taught by a non-striking teacher. The magnitude of the effect is roughly equivalent to a quarter of a years' lost learning despite the average strike duration in these schools representing only seven per cent of official school days that year. This mismatch may indicate that strikes have lingering disruptive effects on student learning or striking teachers are of lower quality than non-striking teachers. Another reason for the mismatch is that the calculated effect size is upwardly biased.

Fixed effects estimations also identified larger strike effects for students attending rural as opposed to urban schools and for students who are weaker academically. These results imply that unionization and industrial action may augment existing inequalities in the provision of education in South Africa.

Unfortunately, questions remain about making causal inferences from the estimates identified. Although it is expected that lost teaching due to strike action would lower student achievement, the fixed effects estimation strategy could not control adequately for unobserved teacher characteristics which may inform both a teacher's decision to strike and influence student learning. Application of a technique by Altonji et al (2005) suggests that it is not possible to rule out that the negative strike effects observed in the poorest schools could be due to the confounding effects of omitted variable bias.

11. References

Altinok, N. and Kingdon, G. (2012) 'New Evidence on Class Size Effects : A Pupil Fixed Effects Approach', *Oxford Bulletin of Economics and Statistics* , vol. 74, no. 2, pp. 203-234.

Altonji, J., Elder, T. and Taber, C. (2005) 'Selection on Observed and Unobserved Variables: Assessing the Effectiveness of Catholic schools', *Journal of Political Economy*, vol. 113, no. 1 (February), pp. 151-184.

Baker, M. (2011) *Industrial Action in Schools: Strikes and Student Achievement. NBER Working Paper Series No.16846*, Cambridge, Massachussets: National Bureau of Economic Research, Available: http://www.nber.org/papers/w16846 [May 2013].

Belot, M. and Webbink, D. (2010) 'Do Teacher Strikes Harm Educational Achievement of Students?', *Labour*, vol. 24, no. 4, pp. 391–406.

Chisholm, L. (1999) 'The Democratization of Schools and Politics of Teachers' Work in South Africa', *Compare: A Journal of Comparative and International Education*, vol. 29, no. 2, pp. 111-126.

Clotfelter, C.T., Ladd, H.F. and Vigdor, J.L. (2009) 'Are Teacher Absences Worth Worrying About?', *Education Finance and Policy*, vol. 4, no. 2 Spring, pp. 115-149.

Clotfelter, C.T., Ladd, H.F. and Vigdor, J.L. (2010) 'Teacher Credentials and Student Achievement in High School: A Cross-Subject Analysis with Student Fixed Effects', *Journal of Human Resources*, vol. 54, no. 3.

Cohen, J. (1988) *Statistical power analysis for the behavioral sciences*, 2nd edition, Hillsdale, NJ: Lawrence Erlbaum.

Department of Education (2003) *Revised National Curriculum Statement Grades R-9 (Schools)*, Pretoria: Department of Education, Available: http://www.info.gov.za/view/DownloadFileAction?id=70257 [12 June 2013].

Education Labour Relations Council (2010) 'Teaching not an 'essential service'', *The New Negotiator*, January to March, Available: http://www.elrc.org.za/UploadedDocuments/n%20negotiator%2003-10.pdf [May 2013].

Freier, R. and Storck, J. (2012) *The Treatment Effect of Attending a High-Quality School and the Influence of Unobservables*, Berlin: German Institute for Economic Research (DIW Berlin), Available: http://ssrn.com/abstract=2197847 [1 July 2013].

Grimes , P. and Register, C. (1991) 'Teacher Unions and Black Students' Scores on College Entrance Exams', *Indusrial Relations: Journal of Economy and Society*, vol. 30, no. 3, pp. 492–500.

Hill, C.J., Bloom, H.S., Black, A.R. and Lipsey, M.W. (2008) 'Empirical Benchmarks for Interpreting Effect Sizes in Research', *Child Development Perspectives*, vol. 2, no. 3, pp. 172–177.

Hoxby, C. (1996) 'How Teachers' Unions Affect Education Production', *Quarterly Journal of Economics*, August, pp. 671-717.

Kingdon, G. (2006) *Teacher characteristics and student performance in India: A pupil fixed effects approach*, Global Poverty Research Group Working Papers GPRG-WPS-059.

Kingdon, G. and Teal, F. (2010) 'Teacher unions, teacher pay and student performance in India: A pupil fixed effects approach', *Journal of Development Economics*, vol. 91, pp. 278-288.

NEEDU (2012) *National Report 2012: The State of Literacy Learning and Teaching in the Foundation Phase*, Pretoria: NEEDU.

Patillo, K.M. (2012) *Quiet Corruption: Teacher Unions and Leadership in South African Schools. Honours thesis.*, Middletown, Conneticut: Wesleyan University, Available: http://wesscholar.wesleyan.edu/cgi/viewcontent.cgi?article=1912&context=etd_hon_theses [January 2013].

Reddy, V., Prinsloo, C., Netshitangani, T., Moletsane, R., Juan, A. and van Rensburg, D.J. (2010) *An Investigation into Educator Leave in the Ordinary Public Schooling System*, Pretoria: Human Sciences Research Council.

SACMEQ (2010) *SACMEQ III Project Results: Pupil Achievement Levels in Reading and Mathematics*, SACMEQ.

Senate, H.F.V. (1954) *Verwoerd Speaks, Speeches 1948-1966*, Johannesburg: APB Publishers 1966.

Spaull, N. (2013) 'Poverty and Privilege: Primary School Inequality in South Africa', *International Journal of Educational Development*, vol. 33.

Taylor, S. (2011) *Uncovering indicators of effective school management in South Africa usingthe National Schools Effectiveness Study*, Stellenbosch Economic Working Papers: 10/11.

Van der Berg, S. (2008) 'How effective are poor schools? Poverty and educational outcomes in South Africa', *Studies in Educational Evaluation*, vol. 34, pp. 145-184.

World Bank (2010) *Africa Development Indicators 2010: Silent and Lethal - How quiet corruption undermines Africa's development efforts*, Washington, Available: http://siteresources.worldbank.org/AFRICAEXT/Resources/english_essay_adi2010.pdf [July 24 2013].

Zwerling, H.L. (2008) 'Pennsylvania Teachers' Strikes and Academic Performance', *Journal of Collective Negotiations*, vol. 32, no. 3, pp. 151-172.

Appendix

Table A 1: Descriptive statistics of variables in estimations

Variable	Definition	All Schools Mean	Poorest 75% Mean	Wealthiest 25% Mean
Student characteristics				
Young (<11y 3m) *	Student is young for grade 6 (younger than 11 years and 3 months old)	0.026 (0.002)	0.029 (0.003)	0.016 (0.005)
Old (>over 12y 8m) *	Student is old for grade 6 (Older than 12 years & 8 months old) . Reference category: grade correct age.	0.429 (0.011)	0.499 (0.011)	0.202 (0.015)
Female*	Student is female	0.509 (0.006)	0.502 (0.007)	0.53 (0.014)
Student SES	Index of students socio-economic status calculated from 31 assets of household ownership using principal components analysis	2.138 (0.130)	1.043 (0.090)	5.688 (0.159)
SES squared		15.245 (0.846)	7.708 (0.268)	39.688 (1.730)
Lived with parents*	Student lives with their parents	0.73 (0.010)	0.695 (0.011)	0.846 (0.022)
3 or more siblings*	Student has 3 or more siblings	0.541 (0.012)	0.622 (0.011)	0.278 (0.021)
misses 1 daily meal*	Student normally misses at least on meal per week	0.242 (0.008)	0.241 (0.010)	0.242 (0.015)
misses 2 daily meals*	Student normally misses at least 2 meals per week	0.118 (0.006)	0.13 (0.008)	0.077 (0.008)
misses 3 daily meals*	Student normally misses at least 3 meals per week	0.045 (0.003)	0.05 (0.004)	0.028 (0.005)
More than 10 books at home*	Student indicates that they have more than ten books at home	0.282 (0.014)	0.182 (0.010)	0.606 (0.028)
Mother or father has matric*	Student indicates that either mother or father (or both) has completed secondary education	0.428 (0.011)	0.362 (0.012)	0.642 (0.020)
Mother or father has degree*	Student indicates that either mother or father (or both) has a degree.	0.125 (0.009)	0.075 (0.006)	0.286 (0.024)
Speaks English always*	Student indicates speaking English outside school all or most of the time (Reference category: 'never')	0.141 (0.013)	0.073 (0.007)	0.363 (0.036)
Speaks English sometimes*	Student indicates speaking English outside school sometimes (Reference category: 'never')	0.628 (0.014)	0.654 (0.015)	0.542 (0.032)
Double orphan*	Student indicates that both parents are deceased.	0.089 (0.009)	0.099 (0.010)	0.057 (0.023)
Gets help with homework sometimes*	Student gets help with homework sometimes	0.577 (0.014)	0.542 (0.017)	0.692 (0.019)
Gets help with homework most of the time*	Student gets help with homework most of the time.	0.342 (0.014)	0.371 (0.017)	0.247 (0.020)
> 5 days absent*	Self-reported student absenteeism	0.028 (0.006)	0.03 (0.007)	0.024 (0.004)

Variable	Definition	All Schools Mean	Poorest 75% Mean	Wealthiest 25% Mean
Preschool - <= 1 year*	Student attended preschool (includes kindergarten, nursery or reception) for a few months or 1 year	0.37	0.401	0.27
		(0.010)	(0.012)	(0.023)
Preschool - 2 years*	Student attended preschool for 2 years	0.154	0.135	0.212
		(0.007)	(0.008)	(0.014)
Preschool - 3 years*	Student attended preschool for 3 or more years (Reference category: never attended preschool)	0.207	0.147	0.402
		(0.009)	(0.007)	(0.029)
Repeated a grade once*	Self-reported number of times a student has repeated a grade (including grade 6) since they started school. Reference category: never repeated.	0.202	0.225	0.125
		(0.007)	(0.009)	(0.011)
Repeated a grade twice*		0.051	0.062	0.013
		(0.003)	(0.004)	(0.004)
Repeated a grade 3 or more times*		0.03	0.037	0.007
		(0.004)	(0.004)	(0.002)
School characteristics				
Urban*	School is located in urban area. Reference category: rural location.	0.508	0.385	0.906
		(0.025)	(0.026)	(0.040)
School SES	Average socio-economic status of grade 6 students in that school.	2.138	1.043	5.689
		(0.130)	(0.090)	(0.157)
School SES squared		10.307	3.027	33.917
		(0.824)	(0.180)	(1.856)
Building Index (std)	Standardised index of school buildings based on the underlying variable 7 school buildings	0.123	-0.341	1.628
		(0.067)	(0.061)	(0.100)
Equipment Index (std)	Standardised index of school buildings based on underlying variable of the 18 items	0.865	0.577	1.798
		(0.049)	(0.055)	(0.068)
No class library*	Student's classroom does not have a library.	0.57	0.631	0.371
		(0.028)	(0.032)	(0.065)
Class size => 40*	Class size equal to or greater than 40 students, as reported by the school principal.	0.564	0.634	0.337
		(0.028)	(0.031)	(0.063)
Principal has degree*	School principal has a tertiary education - at least a first degree	0.656	0.632	0.734
		(0.028)	(0.033)	(0.054)
Teaching hours of principal	Total hours the principal reports teaching at the school.	7.361	8.461	3.793
		(0.354)	(0.428)	(0.433)
Principal experience as a school head	Principal's total years of experience as a school principal or acting principal.	10.613	11.01	9.325
		(0.475)	(0.567)	(0.795)
Principal is female*	School principal is female.	0.355	0.393	0.231
		(0.029)	(0.034)	(0.055)
Principal instructional leadership*	Principal prioritizes discussing educational objectives with the teaching staff and their professional development	0.489	0.436	0.661
		(0.030)	(0.034)	(0.064)
Teacher characteristics				
Teacher has degree*	Teacher has a tertiary education - at least a first degree	0.458	0.413	0.602
		(0.020)	(0.022)	(0.041)
Teacher is male*	Teacher is male	0.34	0.357	0.284
		(0.018)	(0.020)	(0.038)

Variable	Definition	All Schools Mean	Poorest 75% Mean	Wealthiest 25% Mean
Teacher preservice training: <=1 year*	Teacher has 1 year or less of teacher pre-service training.	0.037	0.026	0.075
		(0.007)	(0.007)	(0.017)
Teacher preservice training: 2 years*	Teacher has 2 years of pre-service training.	0.078	0.09	0.042
		(0.011)	(0.013)	(0.021)
Teacher preservice training: 3 years*	Teacher has 3 years of pre-service training. *Reference category: more than three years of pre-service training.*	0.438	0.515	0.187
		(0.019)	(0.022)	(0.028)
Teacher's age	Teacher's age.	41.663	41.565	41.98
		(0.313)	(0.330)	(0.763)
Teacher's experience	Total number of years a teacher has been teaching.	15.632	15.357	16.523
		(0.353)	(0.378)	(0.809)
Teacher strikes at least one day*	The teacher reports being absent for a strike for at least one day.	0.777	0.833	0.595
		(0.018)	(0.018)	(0.047)
Number of days absent: teacher strike	Total number of days absent for strike in 2007.	11.639	13.906	4.288
		(0.388)	(0.379)	(0.876)
Number of days absent: own illness	Total number of days absent for own illness.	2.784	2.936	2.291
		(0.331)	(0.424)	(0.317)
Number of days absent: funerals	Total number of days absent for funerals.	0.83	0.945	0.457
		(0.076)	(0.091)	(0.121)
Number of days absent: official business	Total number of days absent for official business (e.g. meeting, examination, course)	1.643	1.923	0.738
		(0.140)	(0.170)	(0.174)
Hours spent lesson prep & marking	The total average weekly hours teacher spends on lesson preparation & marking for school, outside school hours	10.022	9.642	11.252
		(0.321)	(0.383)	(0.550)
Home in poor condition/ needs repairs*	Teacher indicates that his/her home is in poor condition or need of major repair.	0.262	0.315	0.088
		(0.019)	(0.022)	(0.021)
Teacher gets teaching advice from principal*	Teacher indicates that school head gives him/her advice on teaching at least once a month.	0.458	0.476	0.401
		(0.022)	(0.026)	(0.044)
Enough sitting places in classroom for students*	Number of sitting places in classroom as indicated by teacher is equal to or exceeds total number of students in class.	0.562	0.503	0.755
		(0.025)	(0.028)	(0.054)
Teacher gets parents to sign student work*	Teacher gets parents or guardians to sign that students have completed their home assignments.	0.589	0.562	0.679
		(0.022)	(0.026)	(0.041)
Teacher's teaching supplies Index	Summative index of the number of teaching support items a teacher reports having in his or her classroom.	0.726	0.691	0.839
		(0.012)	(0.014)	(0.020)
Teacher wrote subject specific test*	Teacher completed SACMEQ teacher test for his/her subject taught.	0.902	0.906	0.891
		(0.012)	(0.014)	(0.023)
Observations		24 701	19 114	5 587

Notes: Variables marked with a * are 0/1 indicator variables. Standard errors are in parentheses. Means of all variables calculated using the student-subject dataset. A seven school buildings include school library, school or community hall, teacher/staff room, separate office for School Head, store room, special area for guidance and counselling, and cafeteria/shop/kiosk. B. first aid kit, clock, telephone, typewriter, duplicator, electricity (mains or generator), radio, tape recorder, TV, audio cassette player, CD, player, VCR machine, DVD player, fax machine, photocopier, overhead projector, computer(s), computer room. C. Usable writing board, chalk (or other markers), board duster/eraser, wall chart, cupboard or locker, bookshelves, classroom library or book corner, teacher table, teacher chair.

Table A 2: OLS estimation results

	All Schools				Wealthiest 25% of schools				Poorest 75% of schools			
Specifications	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Dummy: Teacher strikes at least one day	0.0174	0.0345	0.0169	-0.0132	0.0304	0.0456	0.0412	0.0174	0.0289	0.0378	0.0257	0.0023
	(0.039)	(0.038)	(0.045)	(0.048)	(0.050)	(0.049)	(0.045)	(0.046)	(0.046)	(0.045)	(0.056)	(0.065)
Subject Dummies												
Subject test: Reading	-0.0029	-0.0132	-0.0137	-0.022	0.1217***	0.1171***	0.1302**	0.1022**	-0.0414**	-0.0479**	-0.0515**	-0.0513**
	(0.017)	(0.018)	(0.018)	(0.019)	(0.036)	(0.034)	(0.040)	(0.043)	(0.019)	(0.020)	(0.020)	(0.020)
Subject test: Health	0.0485*	0.0304	0.0268	0.0314	-0.1516**	-0.1677**	-0.1539**	-0.1200**	0.1111***	0.0907**	0.0803**	0.0831**
	(0.029)	(0.031)	(0.030)	(0.031)	(0.058)	(0.058)	(0.062)	(0.059)	(0.033)	(0.036)	(0.035)	(0.037)
Student Characteristics												
Young (<11y 3m)	-0.0805*	-0.0851*	-0.0824*	-0.0907**	-0.0414	-0.0552	-0.0383	-0.0398	-0.0544	-0.0551	-0.0541	-0.0649
	(0.047)	(0.046)	(0.045)	(0.045)	(0.132)	(0.129)	(0.129)	(0.128)	(0.051)	(0.050)	(0.048)	(0.050)
Old (>over 11y 3m-12y 8m)	-0.1218***	-0.1214***	-0.1201***	-0.1235***	-0.1478***	-0.1483***	-0.1396**	-0.1322**	-0.1052***	-0.1058***	-0.1048***	-0.1088***
	(0.020)	(0.019)	(0.019)	(0.018)	(0.043)	(0.043)	(0.043)	(0.045)	(0.021)	(0.021)	(0.020)	(0.020)
Female	0.0813***	0.0805***	0.0819***	0.0817***	0.0610**	0.0596**	0.0583**	0.0593**	0.0804***	0.0803***	0.0803***	0.0821***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.026)	(0.026)	(0.025)	(0.027)	(0.016)	(0.016)	(0.016)	(0.017)
SES status	0.0041	0.0046	0.0048	0.0047	0.0445**	0.0451**	0.0411*	0.0395*	0.0095*	0.0095*	0.0093*	0.0095*
	(0.005)	(0.005)	(0.005)	(0.006)	(0.022)	(0.022)	(0.022)	(0.024)	(0.005)	(0.005)	(0.005)	(0.005)
SES status squared	0.0008	0.0008	0.0008	0.0008	-0.0022	-0.0023	-0.0019	-0.0018	-0.0012	-0.0011	-0.0011	-0.0013
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Lived with parents	-0.019	-0.0193	-0.0164	-0.0151	0.0095	0.0062	0.0154	0.005	-0.0262	-0.0253	-0.0203	-0.0166
	(0.020)	(0.020)	(0.020)	(0.021)	(0.053)	(0.052)	(0.051)	(0.055)	(0.021)	(0.021)	(0.021)	(0.022)
3 or more siblings	-0.0677***	-0.0670***	-0.0634***	-0.0612***	-0.0630**	-0.0620**	-0.0626**	-0.0698**	-0.0492**	-0.0484**	-0.0455**	-0.0464**
	(0.017)	(0.017)	(0.017)	(0.018)	(0.029)	(0.030)	(0.029)	(0.031)	(0.021)	(0.020)	(0.020)	(0.020)
misses 1 daily meal at least 1x per week	0.0356	0.0346	0.0336	0.0322	-0.0449	-0.0442	-0.0404	-0.0389	0.0687**	0.0664**	0.0628**	0.0605**
	(0.022)	(0.022)	(0.021)	(0.022)	(0.036)	(0.037)	(0.036)	(0.038)	(0.025)	(0.025)	(0.024)	(0.025)
misses 2 daily meals at least 1x per week	-0.0853**	-0.0852**	-0.0894**	-0.0785**	-0.1779**	-0.1801**	-0.1838**	-0.1746**	-0.0553*	-0.0545*	-0.0608**	-0.0565*
	(0.029)	(0.029)	(0.028)	(0.028)	(0.070)	(0.068)	(0.067)	(0.074)	(0.030)	(0.030)	(0.029)	(0.029)

Table A 2 Cont…	All Schools				Wealthiest 25% of schools				Poorest 75% of schools			
Specifications	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
misses 3 daily meals at least 1x per week	-0.0889**	-0.0813*	-0.0837**	-0.0587	-0.2861***	-0.2798***	-0.2733***	-0.2500**	-0.0466	-0.0417	-0.0479	-0.0249
	(0.043)	(0.043)	(0.041)	(0.043)	(0.072)	(0.073)	(0.071)	(0.076)	(0.046)	(0.046)	(0.045)	(0.046)
More than 10 books at home	0.0831***	0.0817***	0.0849***	0.0864***	0.1102**	0.1138***	0.1152***	0.1300***	0.0481*	0.0471*	0.0508*	0.0506*
	(0.023)	(0.023)	(0.022)	(0.023)	(0.033)	(0.032)	(0.033)	(0.032)	(0.029)	(0.028)	(0.028)	(0.029)
Mother or father has matric	0.1052***	0.1030***	0.1009***	0.1017***	0.0935**	0.0950**	0.0993**	0.1071**	0.0978***	0.0955***	0.0934***	0.0904***
	(0.019)	(0.019)	(0.019)	(0.018)	(0.042)	(0.041)	(0.042)	(0.043)	(0.020)	(0.020)	(0.020)	(0.020)
Mother or father has a degree	0.2075***	0.2004***	0.1960***	0.1856***	0.1988***	0.1986***	0.1925***	0.1973***	0.1704***	0.1613***	0.1550***	0.1454***
	(0.029)	(0.029)	(0.028)	(0.029)	(0.044)	(0.044)	(0.044)	(0.046)	(0.042)	(0.041)	(0.041)	(0.041)
Speaks English at home always	0.3284***	0.3146***	0.3094***	0.2879***	0.4256***	0.4191***	0.4287***	0.3956***	0.1294**	0.1297**	0.1292**	0.1320**
	(0.047)	(0.045)	(0.045)	(0.046)	(0.065)	(0.064)	(0.057)	(0.063)	(0.054)	(0.052)	(0.051)	(0.052)
Speaks English at home sometimes	0.1985***	0.1973***	0.1929***	0.1905***	0.2003***	0.1983***	0.1925***	0.1791***	0.2013***	0.1997***	0.1940***	0.1958***
	(0.028)	(0.028)	(0.026)	(0.026)	(0.052)	(0.051)	(0.047)	(0.050)	(0.030)	(0.029)	(0.028)	(0.028)
Double orphan	-0.04	-0.0383	-0.0412	-0.0454	-0.1183	-0.1092	-0.1901	-0.2134	-0.0261	-0.0235	-0.0175	-0.0166
	(0.035)	(0.034)	(0.034)	(0.034)	(0.120)	(0.125)	(0.120)	(0.131)	(0.037)	(0.036)	(0.036)	(0.035)
Gets help with homework sometimes	0.1665***	0.1631***	0.1603***	0.1525***	-0.0844	-0.0867	-0.0743	-0.0872	0.2085***	0.2081***	0.2063***	0.1975***
	(0.038)	(0.038)	(0.038)	(0.037)	(0.079)	(0.079)	(0.076)	(0.082)	(0.039)	(0.038)	(0.039)	(0.037)
Gets help with homework most of the time	0.1156**	0.1136**	0.1127**	0.1083**	-0.2627**	-0.2663**	-0.2592**	-0.2821***	0.2053***	0.2052***	0.2047***	0.1987***
	(0.045)	(0.045)	(0.043)	(0.044)	(0.081)	(0.080)	(0.078)	(0.081)	(0.045)	(0.044)	(0.043)	(0.044)
> 5 days absent	0.1418	0.1375	0.1396	0.1405	-0.0147	-0.0118	-0.005	-0.0304	0.151	0.1517	0.1514	0.163
	(0.131)	(0.127)	(0.123)	(0.128)	(0.080)	(0.080)	(0.077)	(0.080)	(0.146)	(0.142)	(0.133)	(0.137)
Preschool - <= 1 year	0.0919**	0.0877**	0.0896**	0.0896**	0.2075***	0.2069***	0.2027***	0.2086***	0.0623**	0.0585*	0.0619**	0.0657**
	(0.030)	(0.029)	(0.029)	(0.030)	(0.050)	(0.050)	(0.053)	(0.053)	(0.030)	(0.030)	(0.030)	(0.030)
Preschool - 2 years	0.1105***	0.1066***	0.1129***	0.1124***	0.2454***	0.2448***	0.2312***	0.2249***	0.0645*	0.0620*	0.0713**	0.0801**
	(0.031)	(0.030)	(0.030)	(0.029)	(0.054)	(0.054)	(0.057)	(0.055)	(0.033)	(0.032)	(0.031)	(0.032)
Preschool - 3 years	0.1274***	0.1252***	0.1278***	0.1214***	0.2518***	0.2510***	0.2438***	0.2560***	0.0766**	0.0743**	0.0769**	0.0647**
	(0.028)	(0.029)	(0.028)	(0.027)	(0.043)	(0.042)	(0.045)	(0.047)	(0.032)	(0.032)	(0.031)	(0.030)

Table A 2 Cont…	**All Schools**				**Wealthiest 25% of schools**				**Poorest 75% of schools**			
Specifications	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Repeated a grade once	-0.1655***	-0.1665***	-0.1608***	-0.1574***	-0.2602***	-0.2608***	-0.2640***	-0.2620***	-0.1346***	-0.1348***	-0.1327***	-0.1285***
	(0.022)	(0.022)	(0.021)	(0.021)	(0.058)	(0.058)	(0.057)	(0.056)	(0.021)	(0.021)	(0.021)	(0.021)
Repeated a grade twice	-0.2374***	-0.2383***	-0.2323***	-0.2391***	-0.2246**	-0.2287**	-0.2413**	-0.2077**	-0.2207***	-0.2212***	-0.2185***	-0.2293***
	(0.032)	(0.032)	(0.031)	(0.031)	(0.112)	(0.110)	(0.101)	(0.093)	(0.031)	(0.030)	(0.030)	(0.031)
Repeated a grade three or more times	-0.3968***	-0.3922***	-0.3863***	-0.3886***	-0.6321***	-0.6299***	-0.6231***	-0.6113**	-0.3343***	-0.3322***	-0.3336***	-0.3442***
	(0.048)	(0.047)	(0.048)	(0.052)	(0.163)	(0.167)	(0.170)	(0.206)	(0.045)	(0.045)	(0.048)	(0.051)
School Characteristics												
Urban	0.0496	0.0423	0.0345	0.0294	0.0137	0.025	0.0024	-0.0915	0.1179**	0.0996*	0.0899	0.0879
	(0.057)	(0.056)	(0.054)	(0.055)	(0.107)	(0.113)	(0.097)	(0.093)	(0.057)	(0.058)	(0.056)	(0.057)
School SES	0.0138	0.0117	0.0097	0.0054	0.319	0.3306	0.3629*	0.4391**	-0.0015	-0.0018	-0.0071	-0.0111
	(0.027)	(0.027)	(0.025)	(0.025)	(0.258)	(0.248)	(0.213)	(0.212)	(0.033)	(0.032)	(0.029)	(0.029)
School SES squared	0.0198***	0.0197***	0.0197***	0.0196***	-0.0165	-0.0171	-0.0196	-0.0237	0.0207*	0.0230**	0.0235**	0.0279**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.022)	(0.021)	(0.017)	(0.017)	(0.012)	(0.012)	(0.011)	(0.011)
Building Index (std)	0.0377	0.0324	0.0275	0.0187	0.1009*	0.0954	0.072	0.0458	-0.0074	-0.0065	-0.0109	-0.0079
	(0.030)	(0.030)	(0.029)	(0.028)	(0.060)	(0.059)	(0.047)	(0.046)	(0.032)	(0.032)	(0.031)	(0.032)
Equipment Index (std)	0.0315	0.0407	0.0294	0.0324	0.2313**	0.2243**	0.1592**	0.1246*	0.0268	0.0355	0.0256	0.0266
	(0.037)	(0.036)	(0.036)	(0.037)	(0.092)	(0.093)	(0.072)	(0.071)	(0.037)	(0.037)	(0.037)	(0.039)
No class library	-0.0147	-0.0241	-0.0196	-0.0368	-0.0149	-0.0297	0.0035	-0.0039	-0.0443	-0.0449	-0.0456	-0.0439
	(0.039)	(0.037)	(0.036)	(0.037)	(0.051)	(0.053)	(0.043)	(0.048)	(0.044)	(0.043)	(0.042)	(0.045)
Class size => 40	0.0224	0.0192	0.0289	0.0321	-0.0444	-0.0484	-0.0625	-0.0605	0.0419	0.0425	0.0524	0.0562
	(0.046)	(0.045)	(0.046)	(0.047)	(0.074)	(0.074)	(0.062)	(0.065)	(0.054)	(0.053)	(0.053)	(0.056)
Principal has tertiary degree	-0.0223	-0.0303	-0.0325	-0.0255	-0.1308**	-0.1427**	-0.1557**	-0.1229**	-0.0236	-0.0344	-0.0363	-0.0454
	(0.043)	(0.042)	(0.041)	(0.042)	(0.063)	(0.062)	(0.052)	(0.056)	(0.044)	(0.044)	(0.044)	(0.046)
Teaching hours of principal	0.004	0.0049	0.0036	0.0046	0.0151	0.0167	0.0152	0.011	0.0054	0.0061	0.005	0.0056
	(0.005)	(0.005)	(0.005)	(0.005)	(0.011)	(0.011)	(0.010)	(0.011)	(0.005)	(0.005)	(0.005)	(0.005)
Years principal has been a school head	-0.0011	-0.0012	-0.0011	-0.0014	-0.0021	-0.0025	-0.0008	-0.0012	-0.002	-0.0023	-0.002	-0.0027
	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)	(0.004)	(0.005)	(0.002)	(0.002)	(0.002)	(0.002)

Table A 2 Cont…	All Schools				Wealthiest 25% of schools				Poorest 75% of schools			
Specifications	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Principal is female	0.0332	0.0407	0.0257	0.0153	0.0631	0.0794	0.1079*	0.1030*	0.0445	0.0468	0.0323	0.0214
	(0.043)	(0.041)	(0.041)	(0.042)	(0.067)	(0.068)	(0.057)	(0.055)	(0.045)	(0.044)	(0.044)	(0.047)
Principal engages in instructional leadership	-0.0022	0.0045	-0.0024	-0.0031	-0.0007	0.0036	0.0344	0.0348	-0.022	-0.0128	-0.0191	-0.0234
	(0.035)	(0.034)	(0.035)	(0.036)	(0.058)	(0.060)	(0.051)	(0.055)	(0.039)	(0.039)	(0.039)	(0.041)
Teacher Characteristics												
Teacher has degree		0.0698**	0.0763**	0.0601*		0.0484	0.0013	-0.0491		0.0646*	0.0798**	0.0804**
		(0.031)	(0.031)	(0.032)		(0.055)	(0.052)	(0.050)		(0.035)	(0.033)	(0.034)
Teacher is male		-0.0444	-0.0307	-0.0349		0.0321	0.0295	0.0202		-0.0436	-0.0269	-0.0326
		(0.030)	(0.028)	(0.029)		(0.048)	(0.049)	(0.043)		(0.035)	(0.032)	(0.033)
Teacher pre-service training: <=1 year		0.0795	0.0602	0.0245		-0.0476	-0.0057	-0.0256		0.1196	0.0798	0.0653
		(0.079)	(0.076)	(0.082)		(0.098)	(0.079)	(0.081)		(0.097)	(0.097)	(0.100)
Teacher pre-service training: 2 years		0.0245	0.0209	0.0361		0.0687	0.2335**	0.2154**		0.0326	0.0361	0.0452
		(0.056)	(0.057)	(0.057)		(0.108)	(0.103)	(0.104)		(0.058)	(0.056)	(0.057)
Teacher pre-service training: 3 years		0.0664**	0.0603*	0.0550*		0.0159	0.0429	0.0717		0.0761**	0.0661*	0.0566
		(0.030)	(0.031)	(0.033)		(0.060)	(0.051)	(0.046)		(0.032)	(0.034)	(0.038)
Teacher's age		-0.0544***	-0.0503**	-0.0481**		-0.0293*	-0.0292	-0.0431**		-0.0492**	-0.0450*	-0.0377
		(0.014)	(0.015)	(0.016)		(0.017)	(0.018)	(0.019)		(0.024)	(0.024)	(0.025)
Teacher's age squared		0.0006***	0.0006***	0.0006***		0.0003	0.0004*	0.0005**		0.0006**	0.0006**	0.0005*
		(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
Teacher's experience			-0.0035	-0.0059*			-0.0064	-0.0041			-0.0061	-0.0084**
			(0.004)	(0.004)			(0.006)	(0.005)			(0.004)	(0.004)
Days absent: own illness			0.0014	0.0024			-0.0028	-0.0009			0.0019	0.003
			(0.003)	(0.003)			(0.006)	(0.006)			(0.002)	(0.002)
Days absent: funerals			0.0044	0.0008			0.0378**	0.0353**			0.0021	-0.0005
			(0.007)	(0.006)			(0.018)	(0.016)			(0.006)	(0.006)
Days absent: official business			-0.0056*	-0.0066*			-0.0033	-0.0053			-0.0056*	-0.0061*
			(0.003)	(0.003)			(0.011)	(0.009)			(0.003)	(0.003)

Table A 2 Cont…	All Schools				Wealthiest 25% of schools				Poorest 75% of schools			
Specifications	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Hours spent on lesson preparation & marking			-0.0011	-0.0007			0.0096**	0.0105**			-0.0042*	-0.0034
			(0.002)	(0.002)			(0.004)	(0.004)			(0.002)	(0.002)
Own home in poor condition/ need of repair			-0.0518	-0.0261			-0.1148	0.0037			-0.0511	-0.03
			(0.034)	(0.036)			(0.084)	(0.077)			(0.035)	(0.037)
Gets monthly teaching advice from principal			0.0567*	0.0736**			0.2006***	0.2423***			0.0357	0.0476
			(0.029)	(0.030)			(0.048)	(0.050)			(0.032)	(0.033)
Enough sitting places in classroom for students			0.0622	0.0548			-0.058	-0.0228			0.0536	0.0458
			(0.040)	(0.040)			(0.059)	(0.054)			(0.042)	(0.043)
Teacher gets parents to sign student work			0.0495	0.0704**			-0.0566	-0.0264			0.0581	0.0735*
			(0.035)	(0.036)			(0.054)	(0.053)			(0.040)	(0.040)
Teacher's teaching supplies Index			0.0681	0.0553			0.2345**	0.2108*			0.0351	0.0094
			(0.111)	(0.126)			(0.093)	(0.111)			(0.130)	(0.142)
Teacher wrote subject specific test			-0.0093				-0.1556*				-0.0121	
			(0.064)				(0.079)				(0.073)	
Teachers' test score (std)				0.0779***				0.0895***				0.0460**
				(0.015)				(0.021)				(0.020)
Constant	-0.6789	0.4040	0.2882	0.2607	-1.3880*	-0.8008	-0.9045	-0.936	-0.7628***	0.1915	0.1263	-0.0221
	(0.112)	(0.333)	(0.363)	(0.387)	(0.759)	(0.851)	(0.835)	(0.795)	(0.115)	(0.518)	(0.529)	(0.547)
R-squared	0.428	0.432	0.436	0.442	0.375	0.378	0.392	0.395	0.156	0.160	0.168	0.170
F-stat	52 (0.000)	50 (0.000)	48 (0.000)	53 (0.000)	68 (0.000)	61 (0.000)	52 (0.000)	48 (0.000)	21 (0.000)	20 (0.000)	18 (0.000)	18 (0.000)
Subject-student obs. (N)	24 701	24 701	24 701	22 382	5 587	5 587	5 587	4 936	19 114	19 114	19 114	17 446
Number of schools	364	364	364	361	84	84	84	83	280	280	280	278

Notes: OLS estimates also include provincial controls not shown. Standard errors were corrected for clustering of errors between subjects within a student (student id as the clustering variable and probability sampling weights included. Statistically significant ***1% level, **5% level, *10% level. Standard errors in parentheses.