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Industrial Actions in Schools:
Strikes and Student Achievement

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Abstract: Many jurisdictions ban teacher strikes on the assumption that they negatively affect student achievement, but there is surprisingly little research on this question. The majority of existing studies make cross section comparisons of the achievement of students who do or do not experience a strike. They conclude that strikes do not have an impact. I present new estimates of this impact of strikes using an empirical strategy that controls for fixed student characteristics at the school cohort level, and a sample of industrial actions by teachers in the province of Ontario. The results indicate that teacher strikes in grades 5 or 6 have negative, statistically significant impact on test score growth between grade 3 and grade 6. The largest impact is on math scores: 29 percent of the standard deviation of test scores across school/grade cohorts.

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Introduction

Unions represent primary and secondary school teachers in many developed countries. How teacher unions impact student achievement has been the subject of a number of previous studies. Much of this research focuses on how unionism effects the production of education, through changes in curriculum, changes in the allocation of resources and changes in the incentives for teachers (e.g., Eberts and Stone 1987, Hoxby 1996, Lovenheim 2009).

A much more direct, and perhaps blunt, impact of unions on educational production is through industrial action. Public policy, at least in the U.S., suggests we know what this impact is and it isn't good. Only 13 states provide teachers with the right to strike (Colasanti 2008). Although strikes can have a multitude of effects, including creating major inconvenience for parents, the more often cited impact in the crusade against teachers' right to strike is on student learning. The logic here is simple: students can't learn if they are not in school. In fact teachers' right to strike is often portrayed as a threat to children's right to learn.

What we actually know about the impact of strikes on student achievement is very little. The few studies available offer conflicting results (e.g., Belot and Webbink 2006, Caldwell and Maskalski 1981, Caldwell and Jeffreys 1983, Johnson 2009 and 2011, Thornicroft 1994, Zirkel 1992, Zwerling 2008), and the identification strategies in many are vulnerable to critique. Given the small number of studies, the more liberal provision of strike rights to teachers in countries other than the U.S., new evidence on this issue is timely.

In this study I examine the impact of teacher strikes on student achievement in the province of Ontario. Teachers in Ontario have had the legal right to strike since 1975 and have exercised it regularly. Between 1975 and 2005 there have been at least 101 teacher strikes that lasted almost 19 instructional days on average. This includes a general strike by both primary

and secondary school teachers in 1997 that for 10 days shut down the public education system in the province. At the start of this period some strikes lasted in excess of 50 instructional days.

The focus here is on strikes in the province's primary schools that occurred in the early 2000s. For this same period the results of curriculum based standardized tests that Ontario students write in grades 3 and 6 in reading, writing and mathematics are available. The primary empirical strategy is to compare the grade 3 through grade 6 change in test scores for school cohorts that experience a strike to the corresponding changes for cohorts that do not.

This empirical framework offers a different perspective than the approaches in most previous studies. A more common strategy is a cross sectional comparison of students who experience a strike to those who do not. The criticism of this more common approach is that school boards, schools and students that experience strikes may be different, most importantly in unobserved ways, than those who don't. A standard omitted variables argument raises the possibility that any estimate of the impact of strikes from these comparisons could be biased. The approach adopted here can potentially control for these unobserved factors to the extent they are fixed at the school board, school or student cohort level.

The results indicate that "long" strikes, which last 10 instructional days or more have significant, negative effects on student performance in reading and especially math. For the latter, the impact of a strike in grade 6 is a reduction in test scores of 29 percent of the standard deviation of scores across school/grade cohorts. In contrast, the estimated impact of strikes using a cross section identification strategy is very small and statistically insignificant, highlighting the contribution of the fixed effects empirical strategy.

Teachers and Collective Bargaining in Ontario

Schools in Ontario are organized into 72 school boards, 60 English language and 12 French language.[1] These boards are members of one of two parallel public school systems in Ontario, one secular and one Catholic. Of the 60 English language boards 29 are Catholic and 31 secular. Of the 12 French language boards 8 are Catholic and 4 are secular.

Teachers at these schools belong to one of four professional associations. Two, the Elementary Teachers' Federation of Ontario and the Ontario Secondary School Teachers' Federation, represent the elementary and secondary teachers in English language secular schools respectively. The Ontario English Catholic Teachers' Association represents teachers in English language Catholic schools. Finally, L'Association des enseignantes et des enseignants franco-ontariens represents teachers at secular and Catholic French language schools.

Teachers in Ontario gained the right to strike, and school boards the right to lock out teachers, through the *School Boards and Teachers Collective Negotiations Act*, Bill 100, of 1975. The Act specified that collective bargaining should occur at the school board level, between the board and the relevant teachers' association. The *Act* also created the *Education Relations Commission* (ERC) whose duties included overseeing collective bargaining, advising the government when work stoppages might impede students' education and collecting data.[2]

Bill 160, the *Education Quality Improvement Act*, reformed this collective bargaining environment in 1997.[3] This Act repealed Bill 100 and placed collective bargaining under the auspices of province's *Labour Relations Act*, effectively standardizing collective bargaining in the education sector with bargaining elsewhere in the labor market. It also removed principals

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[1] There are also 33 School Authorities that are either small geographically isolated areas or schools associated with specific hospitals.
[2] The Act also specified a number of dispute resolution mechanisms particular to collective bargaining in this area.
[3] See Rose (2002) for a detailed overview of this episode.

and vice principals from the bargaining units and reduced the scope of negotiable issues.[4] Finally, the ERC was merged with the *Ontario Labour Relations Board* and its role was reduced to advising government when teacher strikes might jeopardize the school year.

This legislation was part of a package of reforms of the educational sector in Ontario. The government of the time also reduced the amount of money flowing into the educational sector, changed the mechanism used to fund schools, prioritized funding for instruction over administration and introduced the standardized testing of students. These reforms were deeply unpopular with many teachers and led to a 10 day province wide general strike by the teachers in October/November 1997.

An overview of the incidence and duration of teacher strikes in Ontario is provided in figure 1. There is a clear downward trend in the duration of strikes and no real discernable trend in incidence until 2003. Starting in the 2003/04 school year there have been no strikes in the Ontario public school system. This is in part due to the election of a new provincial government in 2002, which had a mandate to bring labour peace to this sector.

The Impact of Strikes

The first order consequence of a teacher strike is the withdrawal of teacher's educational services during the period of the work stoppage. Unless this time is made up, for example by extending the school year, students lose a corresponding number of days of instruction. However, this is the only impact of a strike on instruction if we can imagine teachers and students making a clean break at the end of the day before a strike begins and then picking up smoothly at the same place at the beginning of the day after the strike ends.

There are a number of reasons to believe this scenario is false. First, many of the strikes

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[4] For example, many workload issues (e.g., class size) were made terms of employment.

examined are in excess of 10 instructional days. This is longer than both the winter and spring holidays in the Ontario school system. So just as students take a while to get back to work after a school break, we might expect the same to be true after a strike. Second, curriculums are presumably designed to accommodate holidays. Difficult concepts are not left hanging over a break. In contrast, strikes are not anticipated in curriculums, and so extensive review of material may be required to get students back up to speed after a work interruption. Third, strikes may interact with holidays to result in an extended period away from school for the students. Many of the strikes analyzed are either close to the winter break or at the beginning or end of the school year, significantly reducing the period of *sustained* instruction. Finally, in the days leading up to the strike both students and teachers may be distracted further reducing instruction. Similarly, strikes that are ended by legislation may lead to hard feelings or resentment. While difficult to quantify, each of these factors suggest that actual amount of student instruction lost from a teacher strike might exceed the number of days of the actual work stoppage.

Teacher strikes may also have second order effects on additional educational inputs such as support provided by parents or remedial instruction purchased by parents for their children. These impacts are taken up below in the discussion of the empirical framework.

Previous Literature

Previous studies of the impact of teacher strikes on student achievement provide a range of estimates. Zwerling (2008) is a recent example of research finding no impact of strikes on student achievement. He studies Pennsylvania schools in the period 2002/03 through 2005/06. During this period the average strike lasted just over 10 days. While the primary empirical framework is cross sectional, specifications using lagged dependent variables and a two year change in a school district's average results at a specific grade are estimated to control for

omitted variables.[5] The main message of this study is no relationship between either strike incidence or duration and student achievement in math and reading. This conclusion is consistent with the findings of Thornicrolt's (1994) study of Ohio and Zirkel's (1992) review of the literature.

Evidence of negative effects is mostly from an earlier period. Caldwell and Maskalski (1981) and Caldwell and Jefferys (1983) are examples that find some negative effects. More recently Belot and Webbink (2006) report that teacher strikes in Belgium had a negative impact on students' subsequent labor market earnings.

Johnson (2009) examines many of the same strikes in Ontario investigated in this study. Using a cross sectional empirical design he reports that strikes have a modest negative effect on student achievement in grade 6. For example, a 10 day strike is estimated to reduce the proportion of students achieving the provincial standard (defined below) on the standardized tests in grade 6 by one percentage point. Johnson (2011) provides additional analysis of this sample using a different model that includes school fixed effects. All estimates of the average impact of a strike in grade 3 or 6 are statistically insignificant, but there are statistically significant negative impacts of strikes once schools are distinguished by the education of residents in their surrounding area.

Related evidence comes from other literatures investigating the impact of teacher absences and/or the suspension of instruction on student achievement. In the case of teacher absences instructional time is not reduced, but it is disrupted through the use of substitute teachers. Miller et al. (2008) is a recent study examining this issue. They use teacher fixed effects and an instrument based on local weather conditions to account for unobserved teacher quality

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[5] The main dependent variable is the proportion of students scoring "advanced" and "proficient" on the test.

correlated with absenteeism. They report that each 10 days of teacher absence leads to a decline in math achievement of 3.2 percent of a standard deviation. Clotfelter et al. (2009) and Herrmann and Rockoff (2009) provide further evidence of negative effects. There is also research on learning losses over the summer recess—a suspension of teacher instruction. It suggests "summer learning loss" is equivalent to roughly one month of instruction. The greatest loss is in math computation skills and spelling, and generally more pronounced for math than for reading skills (e.g., Cooper et al. 1996).

Data

The data on student test scores are from the Education Quality and Accountability Office (EQAO) accessed through the Public Economics Data Analysis Laboratory (PEDAL) at McMaster University. These are the results of annual testing of grade 3 and 6 students in math, reading and writing, which commenced in the 1996/97 academic year. The EQAO tests are based on the Ontario curriculum, which the public schools in the province deliver. The timing of the tests corresponds to the completion of the curricula of the primary (grades 1-3) and junior (grades 4-6) divisions. The tests are written in May and June of each school year.

The test results in each subject area categorize students on a four point scale:

1. Level 1 means their skills fall below the provincial standard.

2. Level 2 means they are close to meeting the provincial standard.

3. Level 3 means they are at the provincial standard.

4. Level 4 means they have surpassed the provincial standard.

Test results by school and school board are publicly available on the EQAO website. In 2009 the use of EQAO results for school board planning was formalized through the *The Student*

Achievement and School Board Governance Act.[6] The *Act* specifically charges school boards to develop multi year plans and conduct annual reviews to promote student achievement as measured by EQAO scores. In turn school boards require schools to develop school improvement plans. Other organizations use EQAO scores to rank the performance of schools and school boards in the province.[7] Case studies of schools by the EQAO suggest the results are used locally for everything from identifying specific areas of instruction for improvement to tracking individual student progress.[8]

The data also provide some information on the students writing the tests and the environment in which the tests were written. The students' characteristics available are gender, whether the student is special needs, "gifted", enrolled in French immersion or has English as a second language. Information on whether the student wrote the test under special circumstance (e.g., received extra time) is also provided.

Unfortunately there are not consistent student numbers that allow students to be followed between the grade 3 and grade 6 tests. As a result the primary unit of analysis is the student cohort at the school level. These cohorts will contain primarily, although not exclusively, the same students in grade 3 and 6, because of student mobility.

The test score data used come from the academic years 1998/99 through 2005/06. The test scores for students in the French school boards are excluded from the analysis. The average change in tests scores between grade 3 and grade 6 are much larger for students in these boards

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[6] http://www.e-laws.gov.on.ca/html/source/statutes/english/2009/elaws_src_s09025_e.htm accessed April 13, 2012.

[7] http://www.fraserinstitute.org/report-cards/school-performance/ontario.aspx accessed April 13, 2012.

[8] http://www.eqao.com/Success/Stories.aspx?Lang=E&Aud=Success&App=Success&gr=036&yr=11 accessed April 13, 2012.

than in the other boards with no obvious explanation. Results including the French board schools in the sample lead to larger estimated impacts of strikes. Also, the sample only includes school cohorts that have at least 15 test takers in grade 3 and grade 6, and cohorts are excluded when the number of test takers rises or falls more than 40 percent between grades 3 and 6.

PEDAL has merged data from the 2001 Canadian census with these test score data. The matching is on the basis of the "Forward Sortation Area" (FSA) in which all addresses share the same first three characters of a postal code. Given a school's address, information on the socioeconomic characteristics of residents in the same FSA are linked from the 2001 census.

Information on industrial actions within the Ontario school system was collected from a number of sources. Primary sources of data were databanks maintained by the ERC and the Workplace Information Directorate of the federal government's Department of Human Resources and Skill Development. The final record of industrial actions was checked and corrected against a data bank maintained by the Ontario Ministry of Education[9] as well as information gathered from publications of various school boards and the teachers' professional associations and legislation passed to end some of the strikes.

Table 1 lists the strikes in Ontario's elementary schools over the analysis period. Starting in 1997/98, which is one year before the first observation on grade 3 test scores, there are 11 strikes. This does not include the 10 day general strike in the fall of 1997, which is not included in the analysis because it affected all schools in the province. It also does not include rotating strikes—which are listed in the notes to the table—because in these cases it is not possible to determine which schools within a school board were affected.

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[9] I am indebted to John Donofrio for providing this file.

The number of instructional days lost ranges from 3 to 17, with 6 strikes lasting 2 weeks or more. Both small and large boards from both the Catholic and secular systems experience strikes over the period.

Recall that the ERC's mandate is to decide when a strike jeopardizes the school year. This decision was made for two strikes in the sample: the 17 day strike at the Hamilton Wentworth School Board in 2000/01 and the 13 day strike at the Toronto Catholic School Board in 2002/03. More generally, the ERC does not appear to have a set algorithm to make this decision. Between 1975 and 2002 the completed duration of strikes determined by the ERC to threaten students' education year ranged from 13 to 56 days.

In Ontario, instructional days lost through a strike are typically not made up and this is generally true for the strikes in the sample. The exceptions are the Hamilton-Wentworth strike of 2000/01 after which five professional development days were made instructional days, and the York Catholic Board strike of 1998/99 that was followed by seven additional instructional days scheduled during holidays.[10]

A one month strike of custodial staff closed the schools of the Toronto District School Board for 5 days in April 2001. While this closure is not included in the analysis, the results, coding it as a strike, are very similar to those reported below.[11] Finally, the list of strikes in table 1 differs from the list of strikes provided in Johnson (2009) and (2011) for this period. A reconciliation of the differences is provided in an online appendix.

Empirical Framework

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[10] The primary specification of the strike variable is dichotomous so the days made up in these cases do not affect the coding (since in neither case were all days lost made up). In some regressions a 0/1 variable for "long" strikes of at least 10 days is used.
[11] As reported below the only strikes of at least 10 days have a significant impact on students' test scores. The closure of the Toronto DSB due to the custodial strike adds another short strike to the sample.

I examine the impact of teacher strikes in grades 5 or 6 on grade 3 through grade 6 test score growth measured at the cohort/school/year level. Because the anticipated impact of these strikes is that they lower grade 6 test scores, we would expect cohorts experiencing these strikes to experience lower test score growth than cohorts that do not experience a strike.[12]

Modeling teacher strikes in this way can be rationalized by viewing them as an additional input to an education production function in which students' test results depend on individual level and school level characteristics. In levels the test score equation is

$$(1) \qquad T_{gcs} = X_{gcs}\beta_g + Z_s\delta_g + S_{gcs}\phi_g + S_{g-1cs}\mu_{g-1} + \lambda_{cs} + \varepsilon_{gcs}$$

where T_{gcst} is the gth grade average test score of cohort c at school s, X and Z are student/cohort and school/FSA characteristics respectively, S is a 0/1 dichotomous variable indicating that a strike experienced by cohort c in grade g, λ_{cs} is an unobserved cohort/school fixed effect and ε_{gcs} is a transitory error term. In truth S varies at the board level so will be the same for all cohorts of a given vintage across schools within a given school board.

Many previous studies have estimated equations such as (1) using cross section data. A criticism of this approach is that $E[S,\lambda] \neq 0$ leading to bias in the OLS estimates of the parameters of (1). The estimation approach adopted here involves differencing out these fixed unobserved cohort/school characteristics. While this represents an innovation relative to many previous studies, it clearly relies on the assumption that these unobserved characteristics are fixed. A potential violation of this restriction might arise because it is not possible to follow

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[12] It is also possible to investigate the impact of strikes in grades 3 or earlier in this framework. In this case a negative impact of a strike in grade 3 scores might lead the affected cohort to have higher than average test score growth between grades 3 and 6. This prediction, however, is based on the assumption that strikes do not on average have a permanent effect. Within the fixed effect context the estimates if a strike had a permanent effect or no effect would be observationally equivalent. Estimates for the impact of strikes in grades 2 and 3 are presented in Baker (2011).

individual students over time, and the individuals observed at grade 6 in a cohort will not be exactly the same students observed at grade 3. Therefore, it is necessary to assume that any changes in the unobserved cohort/school factors as a result of student mobility are uncorrelated with the included regressors. While the issue of student mobility is investigated more completely below, note here that because strikes occur at the board level, it not possible to simply switch schools locally to avoid industrial actions.[13] Also, it is clearly necessary to assume there are no unobserved time effects coincident with a strike that impact student scores. A more flexible specification that allows slow changing unobserved cohort/school characteristics through cohort specific linear trends is not available here because cohorts are only observed at two points in time.

Equation (1) restricts the lagged impacts of strikes to the grade before the test is taken, as longer lags are not empirically important. If strikes only potentially have such short term effects, should they be of interest? There are at least two answers to this question. First, many previous cross section studies find that strikes do not even have short term effects. However, given the potential bias in cross section estimates the existence of short term effects remains an open question. As a general point, it would be interesting to know whether the school year can be shortened arbitrarily by one to two weeks with little impact on student achievement. Second, it is important to recognize the types of long run effects this restriction rules out. The fact that strikes in years before the test have little impact on test scores may indicate that remediation of any deficits in skills and knowledge that the tests evaluate is possible with sufficient time. Also, fade out of positive innovations to students' human capital accumulation is a common finding.

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[13] Another local possibility would be to switch from the secular to the Catholic school system (or vice versa) to avoid, or as a result of, industrial action. However, entrance to Catholic schools is limited to those with Catholic backgrounds and those in Catholic schools have additional reasons to remain in them.

For example some of the gains of class size reductions or programs like Head Start display this characteristic (e.g., Ding and Lehrer 2010, U.S. Department of Health and Human Services 2010). However, any diversion of resources necessary to achieve this result may have long run impacts not captured here. Also, the restriction does not rule out longer term impacts of a lower test score in the year a strike occurs. For example, these could arise if the test score was an input to future schooling decisions or to student self esteem. Short term impacts of strikes do not necessarily imply these sorts of effects exist, but they would be harder to imagine if there were not short term impacts. Therefore, all long term impacts of strikes are not precluded by the empirical specification, however any impact that does exist (e.g., a diversion of resources) must be consistent with no higher order lagged effect of strikes on test score growth.

It is also important to recognize that the empirical framework potentially identifies the total impact of a teacher strike on student achievement (e.g., Todd and Wolpin 2003). The cognitive input directly associated with a strike is teachers' services. A strike decreases the amount of these services that a child receives. However, a strike may also induce adjustments in other inputs such as the amount of time children receive from their parents. In the current context the estimates of the μ's will reflect the total impact of these direct and indirect effects. Importantly they cannot identify the all else equal impact of a withdrawal of teachers' services due to a strike (i.e., the parameter on this input in the education production function). While this total effect is of interest, an obvious limitation to the external validity of the inference is that it requires that these indirect effects on other inputs be on average the same in any new application.

Taking the grade 6/grade 3 difference of equation (1) at the cohort level yields

$$(2) \qquad \Delta_g T_{cs} = X_{6cs}\beta_6 - X_{3cs}\beta_3 + (\delta_6 - \delta_3)Z_s + S_{6cs}\phi_6 + S_{5cs}\mu_5 - S_{3cs}\phi_3 - S_{2cs}\mu_2 + \Delta_g \varepsilon_{cs}.$$

$\Delta_g T_{cs}$ is the grade 3 through 6 change in the average test score of cohort c at school s. Because

there is only one observation for the school/FSA characteristics, Z, only the grade 3/grade 6

change in the parameter on these variables is identified. The school/cohort fixed effect λ_{cs}

differences out eliminating any bias from the correlation of this effect with the strike variables.

The sample cohorts are selected such that $S_{3cs} = 0$ and $S_{2cs} = 0$. Strikes in grade 3 and

lower are not examined because it is not possible to distinguish a permanent impact of a strike in

these grades from the cohort fixed effect (see footnote 12). Imposing this sample selection yields

the estimating equation

$$(3) \qquad \Delta_g T_{cs} = X_{6cs}\beta_6 - X_{3cs}\beta_3 + (\delta_6 - \delta_3)Z_s + S_{6cs}\phi_6 + S_{5cs}\mu_5 + \Delta_g \varepsilon_{cs}.$$

The regressions are estimated by OLS and standard errors are robust to clustering at the school

board level.

School/cohorts experiencing strikes in grades 5 and 6 are pooled with school/cohorts that

experienced no strikes in any grades—the control group.[14] School boards that do not experience

a strike may nevertheless experience labor tension or more formally a "work to rule" campaign

during which services not directly specified in the employment contract, such as extra curricular

activities, are withdrawn.[15] This begs the question of why labor tension boils over into a strike at

one board and not at another. The primary concern for the analysis is if this is due to unobserved

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[14] An alternative would be to pool all the data and define variables to separately capture the impact of the strikes in the different grades. This option is not pursued because estimating the effects in separate samples is a convenient expository device and also facilitates well defined control groups. For example, when estimating the impact of strikes in grade 5 or 6 any cohorts who were affected by strikes in grade 2 or 3 are omitted from the control group. In a pooled sample these cohorts will be part of the control group for the estimation of the grade 5 and grade 6 strike effects. This said, pooling the data leads to estimates that are almost identical in both magnitude and statistical significance.

[15] Examples of the types of services withdrawn are supervision of co- and extra-curricular activities and attendance at administrative meetings.

factors that also affect student test scores. The working assumption of the analysis is that these unobserved factors are fixed at the cohort/school level and therefore difference out in (2).

The measures of student achievement (the dependent variable) are a cohort's average score on the reading, writing or math tests respectively. The controls for cohort attributes, X, are the proportions of the cohort who are female, receiving special support, "gifted", enrolled in French immersion, have English as a second language and who wrote the test.[16] There is also a full set of year effects, a dummy variable for Catholic boards and their interactions. The school/FSA characteristics, from the 2001 census, are average household income, the percentage of households headed by a single mother, the percentage of the population age 20 or older who do not have a high school diploma, the percentage of the population who are immigrants and arrived in Canada in 1981 or later, the percentage of the population who are visible minorities, and the percentage of the population age 16 and up who are unemployed.

Note that it is not possible to directly estimate the impact of all the strikes listed in table 1. $\Delta_g T_{cs}$ links grade three and six test scores that are three calendar years apart. Valid grade 3 scores are only available for cohorts that experienced grade 5 or grade 6 strikes in 2000/01 through 2002/03. To see why, consider a cohort that experienced the 1998/99 strike at Waterloo Region District School Board when they were in grade 6. To construct ΔT_{cs} for this cohort would require their grade 3 scores from 1995/96. However, the data on student tests cores start in

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[16] Information on whether students attended kindergarten is also available for the years 1998-2004. Including a control for the proportion of a cohort who attended kindergarten in regressions using data from this shorter period has no effect on the results for grade 6. In the grade 3 results the estimates are very similar, although the point estimate of the contemporaneous effect of a strike is more likely negative (but still statistically insignificant).

1998/99.[17] The strike information from the earlier years is used however, to identify cohorts that

did not experience strikes over the period.

Results

In table 2 I report same descriptive statistics for the analysis sample. In the first panel is

the number of cohorts and the mean standardized test results for cohorts that did experience a

strike and did not experience a strike respectively. Both the average score on each test and the

proportion of students achieving the provincial standard (test scores of 3 or 4) are reported. For

example, the average score on the grade 6 math test is marginally lower for cohorts that

experienced a strike in grade 5 or 6 than for and cohorts that did not experience a strike over the

period—2.63 versus 2.65. The proportions of students achieving the provincial standard show a

corresponding comparable difference. Similar differences are observed between the two groups

for the reading test but not for the writing test.

In the lower panel are corresponding comparisons for student level control variables used

in the analysis. In most cases the averages for the strike and no strike cohorts are very similar.

An exception is the proportion of cohorts that are in Catholic schools, which is higher in strike

boards. The source of this latter discrepancy can be seen in table 1. Four of the seven strikes

over the period 2000/01 through 2002/03 occurred in Catholic boards. Note that the share of the

cohorts writing the various tests is similar in the two groups. There is no evidence here that

students in cohorts affected by a strike were excused from writing the tests.

Initial estimates of equation (3) for strikes experienced in grade 5 or 6 are reported in the

first two panels of table 3. To demonstrate the impact of adding the FSA variables to the

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[17] Note if a cohort experienced the one of the 2000/01 strikes in grade 6 data from 1997/98
would be required to construct ΔT_{cs}. Therefore, the strikes in this year can only be used as a one
year lagged strike for the cohorts who were in grade 6 in 2001/02.

regressions, results both without (first panel) and with (second panel) these controls are presented. In either case there is a consistently negative impact of a grade 6 strike on test score growth, although only the result for writing is statistically significant. The grade 5 strike effect is much smaller and mostly negative and statistically insignificant.

One way of trying to discover whether the estimated impact of strikes is causal is to look at the impact of longer strikes. Intuitively any adverse impact of a strike would be increasing to some extent in its length. In the next two columns are the results for students who experienced "long strikes" defined those lasting at least 10 teaching days or two weeks of school.[18] Once the sample is limited to long strikes, the impacts of grade 6 strikes are larger and almost all statistically significant. The estimated impact on math score growth is the largest. It is a reduction of roughly 0.095 points for longer strikes, which is 3.6 percent of the mean grade 6 math score in the no strike boards (table 2), or 27 percent of the standard deviation of grade 6 math test scores across these cohorts. The impact on reading scores is just over half as big— roughly 19 percent of a standard deviation. Finally the impact for writing scores is smaller still and only statistically significant when the FSA controls are not included. The grade 5 strike effects are also now larger although still substantively small.

Adding the FSA characteristics do not appear to have a large impact on the inference. Going forward I report results including them as control variables, but the results are very similar when they are excluded.

In the final panel of the table are the results estimated at the board level. Estimating the regressions at the board level captures any student migration across schools within a board. This might be an important consideration if students fled schools particularly hard hit by a strike. It

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[18] For these estimates the boards experiencing shorter strikes are omitted from the sample.

also has the effect of weighting each strike within the sample equally. In the previous results strikes at larger boards implicitly get greater weight because they have more student cohorts. This can be important if there are heterogeneous impacts of a strike across boards. One way of interpreting any difference in results across these approaches is that the cohort level regressions estimate the impact of a strike on the average cohort that experienced one, while the board level regressions estimate the impact for the average board.

The estimates for the impact of contemporaneous strikes on math and reading scores are comparable to the results in the previous panels. However, the standard errors are more than twice as large so the results are no longer statistically significant.

How does a long strike impact different students? In table 4 the effect of a long strike is estimated for different metrics of student achievement. In the first panel are the results for the provincial "pass rate", defined as a score of 3 or higher on the test. For math the impact is a reduction in the grade 3/grade 6 change in the pass rate of just over 4.5 percentage points. This is just under 7½ percent of the average pass rate in the grade 6 math test among the no strike cohorts (table 2). There is also an impact of a grade 6 strike on the pass rate in reading of just over 2.5 percentage points, or almost 4 percent of the average pass rate.

These results can be compared to the cross section estimates of Johnson (2009) who also analyzes the impact of the strikes in this period on EQAO results. The estimates are most comparable to his estimates for strikes of longer than 9 days, with interaction effects for the tests in different subjects (table 7). Although only the interaction for the math test is statistically significant the results indicate that a strike of this length reduces pass rates in reading by 0.24 percentage points, increases pass rates in writing by (-0.24+0.84) 0.60 percentage points and reduces the pass rate in math by (-0.24-2.47) 2.71 percentage points. In comparison the

estimated impact here is more than twice as big for the math test and more than 10 times bigger and statistically significant for the reading test. As noted above none of the estimates for the overall average impact of a strike are statistically significant in Johnson (2011).

The remaining panels of table 4 show how the impact of a long strike plays out across the distribution of test scores. In each subject there is a comparable, statistically significant, reduction in the grade 3/grade 6 change in the proportions of students at the highest score. In writing the impact is largely a redistribution of the top students between scores 3 and 4— consistent with the absence of an impact on the pass rate in this subject in the top panel. In math and reading there are more widespread shifts across the distribution resulting in statistically significant increases in the proportions of students who do not pass the test.

Finally, in table 5 are results by gender. There is a notable gender difference in the point estimates for the math score growth. Males experience the larger impact of a grade 6 strike, and there is some evidence of a lagged impact of a strike on their math score growth.[19] In contrast it is females who experience the larger impact in reading.

Sensitivity Tests

Given that it not possible to follow students from grade 3 to grade 6, there is reason to wonder if there are significant changes in the composition of school cohorts between these grades that are correlated with the strike variable. These could occur, for example, if boards/schools that experience strikes strategically excuse students from writing the tests to maintain their levels of achievement. Alternatively students who experienced a strike might

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[19] When the FSA controls are excluded the estimated impact of a grade 5 strike on males' math score growth is -0047* (0.027).

decide to switch schools or school boards. Others might decide to leave the public school system for a private school.[20]

There are a number of strategies available to address these issues.[21] The first is to see if cohorts that exhibit large changes in the proportion of test takers between grades 3 and 6 have a substantive effect on the results. To do this a new sample is created that excludes cohorts that experienced changes in the proportion of test takers that fall outside the 5th and 95th percentiles of the distribution. The estimates from this new sample are reported in table 6. The point estimates are very similar to the results reported in the first two panels of table 3, although not surprisingly the standard errors are larger.[22]

Next, it is possible to investigate changes in the size of school cohorts that are correlated with the strike variable. Data from the Ontario Ministry of Education provides estimates of enrollment by grade, by school as of the fall of each school year. In table 7 are the results when the dependent variable is defined as the percentage change in cohort enrollment between grade 3 and grade 6 based on these data. Additional lags of the strike variables are specified in these regressions because the decision to move schools in response to a strike may have a longer gestation period then the impact of strikes on student achievement.[23] There is very little

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[20] Another check that was performed was whether the results are sensitive to weighting. The reported regressions are not weighted by cohort size. The mean outcome from a small school/cohort is given the same weight as the mean from a large school/cohort. Weighting the data by cohort size makes very little difference to the results. These estimates are available on request.

[21] Some of the strategies follow the analysis of Card et al. (2010) using these same data.

[22] As a more severe accommodation the regressions for grade 6 were re-estimated excluding any cohort that exhibits a change on the proportion of students writing the test that was greater than +/- 3 percent. This excludes more than two-thirds of the original sample. With the exception of results for the writing test, the point estimates are very similar to those reported in table 7 although the standard errors are larger.

[23] With the additional lags a 7 day strike in the Brandt Haldimand DSB in 1996 is included in the sample.

evidence here of statistically significant or substantive impact of strikes in grades 4 through 6 on changes in cohort enrollment.

It is also possible to more explicitly examine the choices of students in a school's FSA. Students in an FSA have some choice whether to enroll in the local English or French language school, or the English options to enroll in a public or Catholic school, and this choice may be affected by teacher strikes. In the first row of table 8 the impacts of strikes in grades 4 through 6 on the grade 3 through grade 6 change in the proportion of the FSA's students that are enrolled in English language schools is investigated. Note that all these strikes over the period occurred in English language boards. There is no evidence here that students "flee" the English Language boards in response to the strikes over the period.

In the next row the dependent variable is the change in the proportion of the FSA students who are enrolled in English language *secular* schools. In this case I need to distinguish between strikes occurring in secular (public) and Catholic boards, because presumably the proportion would be increasing in a strike in a local Catholic Board and decreasing in strike in a local public board. Note that the impact of a grade 6 strike in a public board is not identified since all strikes between 2001 and 2005 were in Catholic boards. There is again very little evidence here that strikes affect enrollment patterns.

A final exercise is to examine data that matches students' test scores in grade 3 and grade 6. Starting in 2004 the EQAO uses unique student identifiers so that it is possible to match grade 3 and grade 6 test scores for a specific student. One year of this matched data is now available for students who wrote their grade 3 tests in 2004 and grade 6 tests in 2007. Using these data it is possible to estimate the proportion of grade 3 test takers who are in the same school or the same school board when they write the grade 6 tests.

An analysis of these data is presented in table 9. The sample is chosen to match the analysis sample used in the regressions.[24] Because strikes occur at the board level, the primary focus is the comparison between the full sample of students who write a test and the sample of students who are in the same school board in grade 3 and grade 6. Of the groups of students who wrote tests in either grade 3 or 6 83-86 percent were in the same school board in both years.[25] The average test scores of students who remain in the same board for grades 3 and 6 are marginally higher than for the full sample of students, although the difference is quite small. Similarly, the average test score change between grade 3 and grade 6 is very similar in the two samples, although there are systematically marginally better outcomes—by less than one half a percentage point—in the sample of same school board students.

The message of these different analyses is there is no large systematic changes in cohort composition between grade 3 and grade 6 that are correlated with the incidence of teacher strikes. This supports the working assumption of the analysis that any changes in the unobserved cohort/school factors as a result of student mobility are uncorrelated with the included regressors.

Cross Section Estimates

One of the distinguishing features of this study is the attempt to control for fixed unobserved differences between students who experience a strike and those who do not. As noted in the Introduction the more common approach in the literature is to make cross section comparisons of students who do and do not experience a strike. It is worth asking therefore whether this difference in strategy makes a difference here.

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[24] Schools with more than 10% missing student identifiers were also dropped to facilitate the matching of students between 2004 and 2007.
[25] The percentage of students in the same school is 70-72 percent. This is very similar to the estimates of Card et al. (2010) from these data for a sample of urban schools.

In the first panel of table 10 are the cross section estimates from the same sample of cohorts and strikes used for estimates in table 3. In general the cross section estimates do not bear a strong resemblance to the fixed effects results. First, the cross section approach does not capture the negative statistically significant impact of long grade 6 strikes reported in table 3. Second, while all the cross section estimates are statistically insignificant, the point estimates are generally larger for a strike in grade 5 than a strike in grade 6, just the opposite of the result in table 3. Finally, in the cross section results the point estimates are not always larger for longer strikes as was seen in table 3.

Because the there is no need to follow cohorts over time in the cross section approach it is possible to construct estimates directly using all the strikes in table 1. The second panel of Table 10 contains these cross section estimates. Many of the points made about the results in the top panel again hold here. Most of the estimates are small and all are statistically insignificant; in many cases the estimate for longer strikes is smaller than the estimate of all strikes.

Conclusions

Many previous studies of the impact of teacher strikes indicate that they have little impact on student achievement. This is surprising, because evidence from related literatures indicates that interruptions such as teacher absences affect student outcomes. However, much of the previous evidence on teacher strikes is potentially affected by omitted variables bias.

The estimates in this paper, which control for unobserved fixed student characteristics at the school/cohort level, indicate that teacher strikes have a sizable negative effect on test scores at the late primary level (grade 6 scores). The impact is largest for math at 29 percent of the standard deviation of test scores across student cohorts. It is experienced by students across the

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skill distribution. Smaller impacts are estimated for scores in reading and writing tests. The main effect is in the year the strike occurs.

A comparison to the previous literature is drawn by also estimating the impact of teacher strikes using a cross section identification strategy. For either grade the estimated impact using this approach is small and statistically insignificant, demonstrating the value of accounting for unobserved effects.

Online Appendix: A reconciliation of the Strikes listed in Table 1 and the strikes reported in Johnson (2009) and Johnson (2011)

Because there is no central repository of information on industrial actions taken by Ontario teachers, and there are contradictions across the various sources of information on these actions, coding the teacher strikes involves a certain amount of judgment. Here I explain the decisions that led to a different count of the number of strikes during the sample period from that reported in Johnson (2009) and Johnson (2011). Note, the identity of the strikes is not reported in Johnson (2011), but because the count of strikes per year is the same as in Johnson (2009), I use the information in Johnson (2009) for this reconciliation.

Johnson (2009) reports four additional strikes in the year 1998/99. They are at the Halton DSB, The Peterborough, Victoria, Northumberland, Clarington (PVNC) Catholic DSB, the Simcoe Muskoka Catholic DSB and the Thunder Bay Catholic DSB. I do not include these strikes in the analysis. The reasons for excluding these strikes are:

- *The Halton DSB*: This was a rotating strike as documented in the notes to table 1.

- *The PVNC Catholic DSB*: The record of strikes maintained by the Ontario Ministry of Education documents a strike at this board of 11 days (September 14-29, 1998) affecting 3358 students and 190 teachers, which was ended by legislation on September 28 1998. It also records that the strike was by the elementary teachers at this Board. However, other documents suggest that the strike was by the secondary teachers. First the legislation ending the strike, "The Back to School Act, 1998" applies to "The bargaining unit composed of every Part X.1 teacher, other than occasional teachers, who is employed by the Peterborough Victoria Northumberland and Clarinton (sic) Catholic District School Board and is assigned to one or more secondary schools or to perform duties in respect of such schools all or most of the time." (accessed at http://www.e-laws.gov.on.ca/html/repealedstatutes/english/elaws_rep_statutes_98b13_e.htm on August 17, 2011). Second, a fax sent out by the Ontario English Catholic Teachers Association (OECTA) dated September 14 1998 reports that "Weekend talks ended in a lockout in Peterborough, Victoria, Northumberland and Clarington last night. An estimated 185 teachers and 3,000 students at four schools are affected.", and on September 23, 1998 a fax makes reference to the strike at "Peterborough Secondary" (accessed at http://www.oecta.on.ca/faxagenda/faxag1998/98sept.htm on January 22, 2010). According to information provided at the PVNC Catholic DSB website (http://www.pvnccdsb.on.ca/schools/secondary.asp) this school board had 4 secondary schools in 1998/99.

- *The Simcoe Muskoka Catholic DSB*: The record of strikes maintained by the Ontario Ministry of Education documents an 8 day rotating strike of secondary school teachers in September of this year.

- *Thunder Bay Catholic DSB*: The record of strikes maintained by the Ontario Ministry of Education documents that this strike occurred on September 1/2 1998 and that no students were affected. This is because it occurred before the start of the school year.

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Table 1: Strikes in Ontario Elementary Schools 1997/98 through 2005/06

Year	School Board	Strike Days	Make up Days	Preceded by WTR (days)	Students Affected
1998/99	Simcoe County DSB	9		No	6160
1998/99	York Catholic SB	15	7	No	31011
1998/99	York Region DSB	5		No	54,412
1998/99	Waterloo Region DSB	5		No	36,395
2000/01	Hamilton-Wentworth DSB	17	5	No	40,587
2000/01	Sudbury Catholic SB	3		7	5,952
2000/01	Keewatin-Patricia DSB	10		No	4,606
2000/01	Lambton-Kent DSB	14		19	19,037
2002/03	Simcoe Muskoka Catholic SB	11		19	15,475
2002/03	Toronto Catholic SB	13		9	68,554
2002/03	Windsor-Essex Catholic SB	5		10	18,411

Notes: A general strike of all boards, October 27-November 7 1997, is excluded from this list. The 1998/99 strikes exclude rotating strikes of one day in the York Catholic School Board and Halton District School Board, of 6 days in the York Region District School Board and a one day full strike in Thunder Bay District School Board before the school year. WTR ~ work to rule campaign.

Table 2: Descriptive Statistics-EQAO Data

	Strike in Grades 5 or 6	No Strikes
Number of Cohorts	1054	8903
Test Results		
Math Score	2.63	2.66
	(0.38)	(0.35)
Reading Score	2.63	2.65
	(0.28)	(0.27)
Writing Score	2.63	2.63
	(0.24)	(0.24)
Math Pass Rate	0.59	0.61
	(0.19)	(0.19)
Reading Pass Rate	0.62	0.64
	(0.16)	(0.16)
Writing Pass Rate	0.58	0.59
	(0.15)	(0.16)
Student Characteristics		
Female	0.49	0.49
Special Support	0.09	0.10
Gifted	0.02	0.01
English as a Second Language	0.03	0.03
French Immersion	0.03	0.05
Catholic	0.84	0.31
Share of Cohort Taking Math Test	0.92	0.92
Share of Cohort Taking Reading Test	0.91	0.91
Share of Cohort Taking Writing Test	0.88	0.91

Notes: The tests are marked on a four point scale. A "pass" is defined by achieving the Provincial standard, which is a score of 3 or 4. The reported means are the average of the school/grade cohort means in the indicated school boards.

Table 3: Estimates of the Impact of Teacher Strikes in Grade 5 and Grade 6 on the Grade 3 through Grade 6 Change in Student Test Scores.

	All Strikes		Long Strikes	
	Strike in Grade 6	Strike in Grade 5	Strike in Grade 6	Strike in Grade 5
	No FSA Controls			
Math	-0.043	-0.007	-0.097***	-0.020
	(0.065)	(0.021)	(0.031)	(0.021)
Reading	-0.019	0.002	-0.045*	0.016
	(0.037)	(0.024)	(0.023)	(0.013)
Writing	-0.026*	-0.017*	-0.030*	-0.018*
	(0.013)	(0.010)	(0.015)	(0.010)
	FSA Controls			
Math	-0.039	-0.003	-0.094***	-0.017
	(0.066)	(0.023)	(0.035)	(0.023)
Reading	-0.028	-0.002	-0.058**	0.010
	(0.039)	(0.022)	(0.024)	(0.013)
Writing	-0.027*	-0.017	-0.031	-0.019*
	(0.016)	(0.011)	(0.020)	(0.011)
	Board Level Regressions			
Math	0.024	-0.039	-0.120	-0.049
	(0.145)	(0.041)	(0.080)	(0.042)
Reading	-0.019	-0.019	-0.061	-0.008
	(0.084)	(0.027)	(0.043)	(0.023)
Writing	0.003	-0.014	-0.025	0.001
	(0.038)	(0.024)	(0.038)	(0.029)

Notes: The reported statistics are the estimated parameter on the strike variables in equation (2). Standard errors in parentheses. "Long strikes" are 10 instructional days or longer. *, **, *** denote statistically significant at the 10, 5, 1 percent level, respectively.

Table 4: Estimates of the Impact of Long Teacher Strikes in Grade 5 and Grade 6 on the Grade 3 through Grade 6 Change in Student Test Scores by Markers of Student Achievement.

	Strike in Grade 6	Strike in Grade 5
	Provincial Pass Rate	
Math	-0.046**	-0.011
	(0.022)	(0.015)
Reading	-0.026**	0.007
	(0.012)	(0.007)
Writing	-0.007	-0.002
	(0.010)	(0.008)
	Score=1	
Math	0.021**	0.011
	(0.008)	(0.008)
Reading	0.008	-0.004
	(0.010)	(0.006)
Writing	0.001	0.009**
	(0.009)	(0.004)
	Score=2	
Math	0.025	-0.001
	(0.016)	(0.011)
Reading	0.018**	-0.003
	(0.008)	(0.007)
Writing	0.006	-0.007
	(0.006)	(0.005)
	Score=3	
Math	-0.008	0.005
	(0.009)	(0.007)
Reading	-0.002	0.009
	(0.010)	(0.008)
Writing	0.017*	0.005
	(0.008)	(0.011)
	Score=4	
Math	-0.028***	0.004
	(0.007)	(0.006)
Reading	-0.024***	-0.002
	(0.005)	(0.005)
Writing	-0.024***	-0.007
	(0.004)	(0.006)

Notes: The reported statistics are the estimated parameter on the strike variables in equation (2). Standard errors in parentheses. "Long strikes" are 10 instructional days or longer. *, **, *** denote statistically significant at the 10, 5, 1 percent level, respectively.

Table 5: Estimates of the Impact of Long Teacher Strikes in Grade 5 and Grade 6 on the Grade 3 through Grade 6 Change in Student Test Scores by Gender.

	Strike in Grade 6	Strike in Grade 5	Strike in Grade 6	Strike in Grade 5
	Males		Females	
Math	-0.124***	-0.044	-0.069*	0.013
	(0.037)	(0.028)	(0.037)	(0.020)
Reading	-0.045	0.008	-0.055**	0.022
	(0.032)	(0.014)	(0.023)	(0.024)
Writing	-0.027	-0.040***	-0.024	-0.010
	(0.023)	(0.014)	(0.020)	(0.013)

Notes: The reported statistics are the estimated parameter on the strike variables in equation (2). Standard errors in parentheses. "Long strikes" are 10 instructional days or longer. *, **, *** denote statistically significant at the 10, 5, 1 percent level, respectively.

Table 6: Estimates of the Impact of Teacher Strikes on the Grade 3 through Grade 6 Change in Student Test Scores, Dropping Cohorts with Large Changes in the Proportion of Eligible Students Writing the Test

	All Strikes		Long Strikes	
	Strike in Grade 6	Strike in Grade 5	Strike in Grade 6	Strike in Grade 5
Math	-0.035	0.013	-0.099**	-0.001
	(0.073)	(0.021)	(0.039)	(0.021)
Reading	-0.015	-0.004	-0.046*	0.006
	(0.040)	(0.021)	(0.027)	(0.013)
Writing	-0.021	-0.014	-0.027	-0.016*
	(0.018)	(0.009)	(0.022)	(0.010)

Notes: The reported statistics are the estimated parameter on the strike variable in equation (2). Standard errors in parentheses. "Long strikes" are 10 instructional days or longer. Large changes in the proportion of a cohort writing fall outside the 5th and 95th percentiles of the distribution of this variable across cohorts. *, **, *** denote statistically significant at the 10, 5, 1 percent level, respectively.

Table 7: Estimates of the Impact of Teacher strikes on the Grade 3 through Grade 6 Percentage Change in Cohort Enrollment

All Strikes			Long Strikes		
Strike in Grade 6	Strike in Grade 5	Strike in Grade 4	Strike in Grade 6	Strike in Grade 5	Strike in Grade 4
0.034	0.000	0.005	0.017	0.000	0.009
(0.022)	(0.015)	(0.018)	(0.020)	(0.015)	(0.019)

Notes: The reported statistics are the estimated parameter on the strike variables in equation (2) plus an additional lag. Standard errors in parentheses. Enrolment is measured as of the fall of the school year. "Long strikes" are 10 instructional days or longer. *, **, *** denote statistically significant at the 10, 5, 1 percent level, respectively.

Table 8: Estimates of the Impact of Teacher strikes on the Grade 3 through Grade 6 Percentage Change in Schools' Enrollment of Local Students

	All Strikes			Long Strikes		
	Strike in Grade 6	Strike in Grade 5	Strike in Grade 4	Strike in Grade 6	Strike in Grade 5	Strike in Grade 4
Proportion of Students in English Language Schools						
	0.001	0.001	0.001	-0.000	0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
Proportion of Students in English Language Public Schools						
Public Strikes	NA	-0.005 (0.005)	-0.003 (0.006)	NA	-0.005 (0.005)	-0.003 (0.006)
Catholic Strikes	-0.001 (0.003)	-0.001 (0.003)	0.000 (0.003)	-0.001 (0.003)	-0.002 (0.003)	-0.001 (0.003)

Notes: The reported statistics are the estimated parameter on the strike variable in equation (2). Standard errors in parentheses. NA denotes that the indicated parameter is not identified. Enrolment is measured as of the fall of the school year. "Local students" reside with a school's Forward Sortation Area (FSA). "Long strikes" are 10 instructional days or longer. *, **, *** denote statistically significant at the 10, 5, 1 percent level, respectively.

Table 9: A Comparison of Students who Remain in the Same School Board Between Grade 3 and 6 to the full Sample of Students based on Matched Data for 2004 and 2007.

|		Grade 3		Grade 6	
		Full Sample	Same Board	Full Sample	Same Board
		102114	87837	104937	86891
		(100)	(0.86)	(100)	(0.83)
Math Test	Score	2.77	2.78	2.70	2.72
	% missing	0.053	0.047	0.045	0.032
Reading Test	Score	2.64	2.65	2.72	2.74
	% missing	0.081	0.074	0.047	0.032
Writing Test	Score	2.71	2.72	2.79	2.80
	% missing	0.070	0.063	0.042	0.028
		Full Sample		Same Board	
Change in Math Score		-0.067		-0.063	
Change in Reading Score		0.085		0.088	
Change in Writing Score		0.074		0.078	

Notes: Percentages in parentheses. The Full Sample includes all students writing the indicated test while the Same Board Sample includes students who were in the same school board for the grade 3 and grade 6 tests. % missing is the proportion of students in the cohort who have no score for the indicated test. Test score changes are between grades 3 and 6.

Table 10: Cross Section Estimates of the Impact of Teacher Strikes on Student Test Scores

	All Strikes		Long Strikes	
	Strike in Grade 6	Strike in Grade 5	Strike in Grade 6	Strike in Grade 5
Base Sample of Strikes				
Math	-0.016	-0.041	-0.056	-0.055
	(0.064)	(0.041)	(0.056)	(0.040)
Reading	-0.013	-0.028	-0.005	-0.022
	(0.041)	(0.026)	(0.042)	(0.027)
Writing	-0.038	-0.034	-0.029	-0.031
	(0.037)	(0.023)	(0.037)	(0.025)
Extended Sample of Strikes				
Math	-0.030	-0.013	-0.041	-0.033
	(0.038)	(0.034)	(0.034)	(0.038)
Reading	-0.016	-0.002	-0.005	-0.007
	(0.022)	(0.024)	(0.027)	(0.026)
Writing	-0.021	0.004	-0.008	-0.008
	(0.022)	(0.024)	(0.027)	(0.028)

Notes: The reported statistics are the estimated parameter on the indicated strike variable on grade 3 test results (upper panel) or grade 6 test results (lower panel). Standard errors in parentheses. "Long strikes" are 10 instructional days or longer. *, **, *** denote statistically significant at the 10, 5, 1 percent level, respectively.

Figure 1: The Incidence and Duration of Teacher Strikes in Ontario's Public Schools
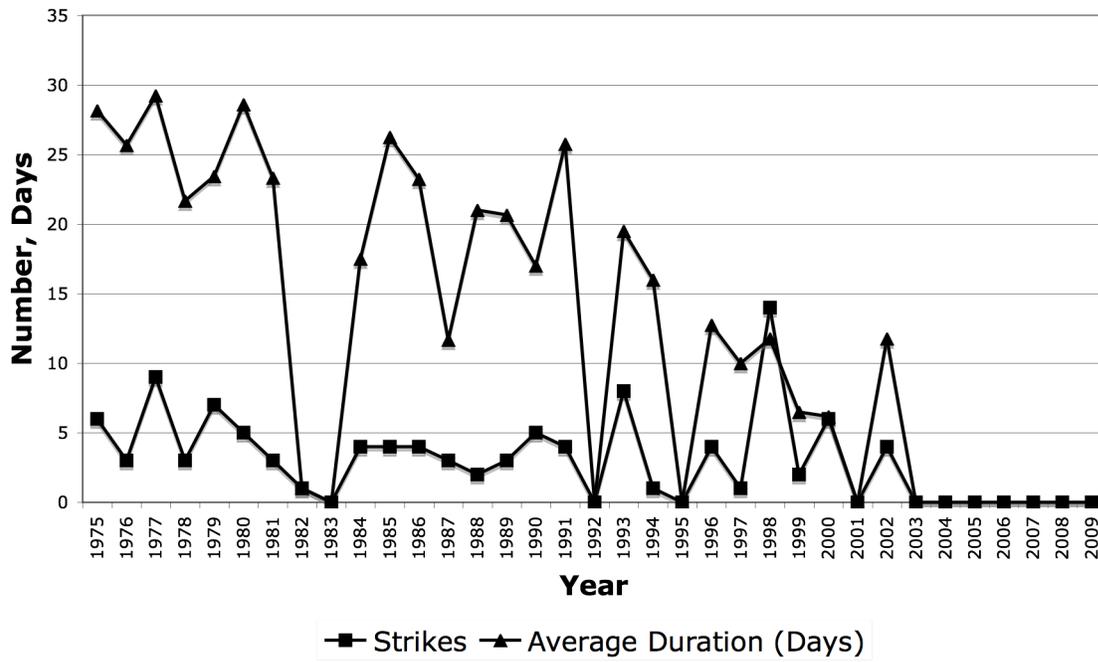
Source: Author's calculation from data sources documented in the text.