Absence, Substitutability and Productivity: Evidence from Teachers

Asma Benhenda

Paris School of Economics

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Still Preliminary

Motivation

- Worker absence : frequent in many countries (2 to 3 % of annual work time in the US, UK & France)
- Empirical evidence on the causal effect of worker absence on productivity is scarce (Clotfelter et al., 2009 ; Duflo et al., 2012 ; Herrmann and Rockoff, 2012)
- Even much less is known on organizations' strategies to cope with this disruptive event
- **I address this issue for teachers** :
  - When a teacher is absent, how does it hurt student achievement ?
  - How easily do schools manage to mitigate this effect with substitute teachers ?

What this Paper Does

- **The aim of this paper is :**
  1. to estimate the effect of teacher absence on student test scores in 9th grade
  2. to study how the effect of teacher absences is mitigated by the assignment of substitute teachers
  3. to study how the effect of substitute teachers depend on their type (tenured substitutes vs. contract teachers)
- **Important questions because :**
  - Impact of worker health and effort on productivity
  - Specific human capital and its relationship with worker substituability
  - Teachers : consequences for educational inequalities

Setting

- **Two types of absences** :
  - Less than a year : not systematically replaced + disruptive for students
  - One year or more : systematically replaced + not disruptive for students

  $\Rightarrow$ disentangle substitute teacher's quality effect from other effects

- **Two main types of substitute teachers** :
  - Tenured teachers assigned to a ZIP code area (*Titulaires sur Zone de Remplacement*)
  - Contract teachers hired on the spot, not trained nor certified

Data and Empirical Approaches :

- **Focus on 9th grade** : Math, French and History teachers and their students
- **Data** : Administrative data matching each teacher to her student (2006-2015) :
- **Empirical Approaches** :
  - Less than a year absences : exploit variations within teacher, across time, controlling for students' fixed characteristics (teacher and student fixed effects)
  - One year or more absences : exploit variations within student, across topics in substitute teachers assignment

Preliminary Results : Less than a Year Absence

- Ten days of non replaced days decrease student test scores by **0.6 % of a standard deviation**
- The number of replaced days on student test scores does not have any statistically significant compensating effect
- By type of substitute teacher :
  - One additional replaced day with a tenured substitute teacher (rather than no class) **mitigates 11 % of the marginal impact of absence**
  - One additional replaced day of substitution with a contract teacher (rather than no class) **increases the marginal impact of absence by 14 %**

Preliminary Results : One Year Absences

- Having a contract teacher for a year rather than a regular teacher decreases student test scores by **8.9 % of a standard deviation**
  - Comparable to what would be the yearly effect of the short term absences
- Having a tenured substitute teacher for a year rather than a regular teacher decreases student test scores by **1.4 % of a standard deviation**

Related Literature

- **Effect of worker absence on productivity** : Miller et al. (2008) ; Clotfelter et al. (2009) ; Duflo et al. (2012) ; Herrmann and Rockoff (2012)
- **Contract Teachers** : Duflo, Dupas and Kremer (2011)
- **Worker substitutability** : Jaravel et al.(2015) ; Hensvik and Rosenqvist (2016) ; Jäger(2016)
- **Instruction time** : Pischke (2007) ; Lavy (2015)

Conceptual Framework (1/2)

Teacher absences can hurt students through different mechanisms :

1. **Loss in instructional time**

2. **Disruption** :
   - substitute teachers do not have any student-specific human capital
   - regular teachers do not accumulate student-specific human capital during their absence

3. **Difference in ability and experience** between the regular and the substitute teachers

Conceptual Framework (2/2)

Different potential mechanisms depending on the type of absences :

1. **Less than a year absences** :
   - Loss in instructional time
   - Disruption
   - Difference of ability/experience between regular and substitute teachers : tenured vs. contract substitute
2. **One year of absence** :
   - Difference of ability/experience between regular and substitute teachers : tenured vs. contract substitute

French Middle School : Outline

- Teachers are topic-specific
- There are no tracks : students keep the same peers for all their different classes
- In 9th grade, students take a centralized standardized test score in French, Mathematics and History

Teacher Absence Leave Regulation

- **Wage setting** :
  - Teachers are civil servants managed centrally by the government
  - Their wages do not vary across schools and do not depend on output
  - Teachers cannot be fired
- **Absence Leave regulation** :
  - Fully paid during their absence leave
  - No limit in the number of days in paid absence each teacher can take per year (unlike the US)

Types of Absences and Substitute Teachers

- **Two types of absences** :
  - One year or more : systematically replaced + no disruption for students
  - Less than a year : not systematically replaced + disruption for students
- **Two types of substitute teachers** :
  - Tenured teachers assigned to a ZIP code area (*Titulaires sur Zone de Remplacement*)
  - Contract teachers hired on the spot

Substitute Teachers Hiring

- **Tenured Substitute Teachers are certified teachers** who :
  - did not get their choice in the centralized assignment procedure to assign teachers (modified version of the deferred acceptance mechanism)
  - choose to become substitute teachers
- **Contract teachers** :
  - Conditions : no criminal record and Bachelor's Degree
  - Centralized online application
  - Shortage : educational authority can directly contact people who are registered to the unemployment office

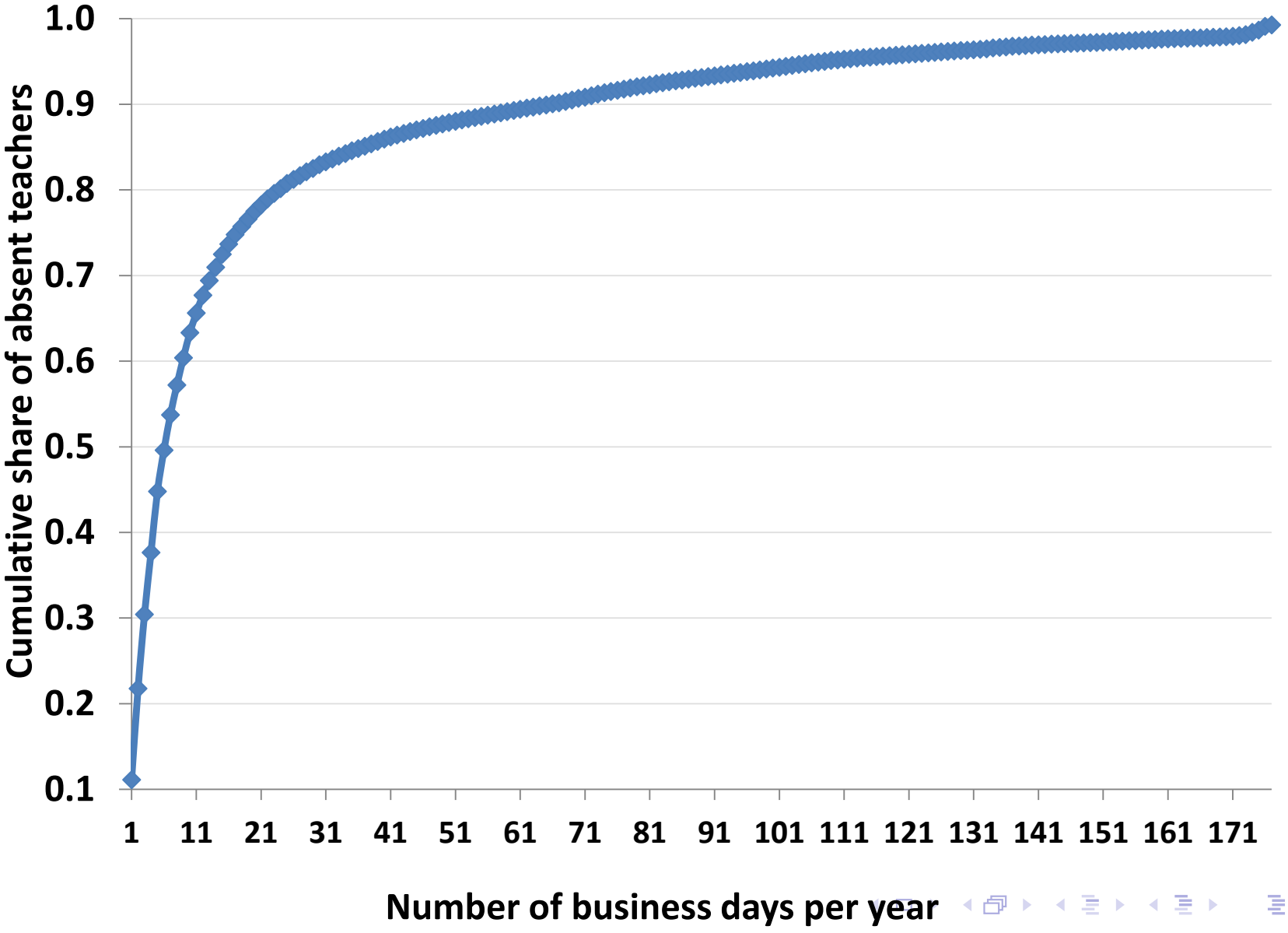
Data

Comprehensive administrative data on teachers and students in middle school (2006 - 2015) :

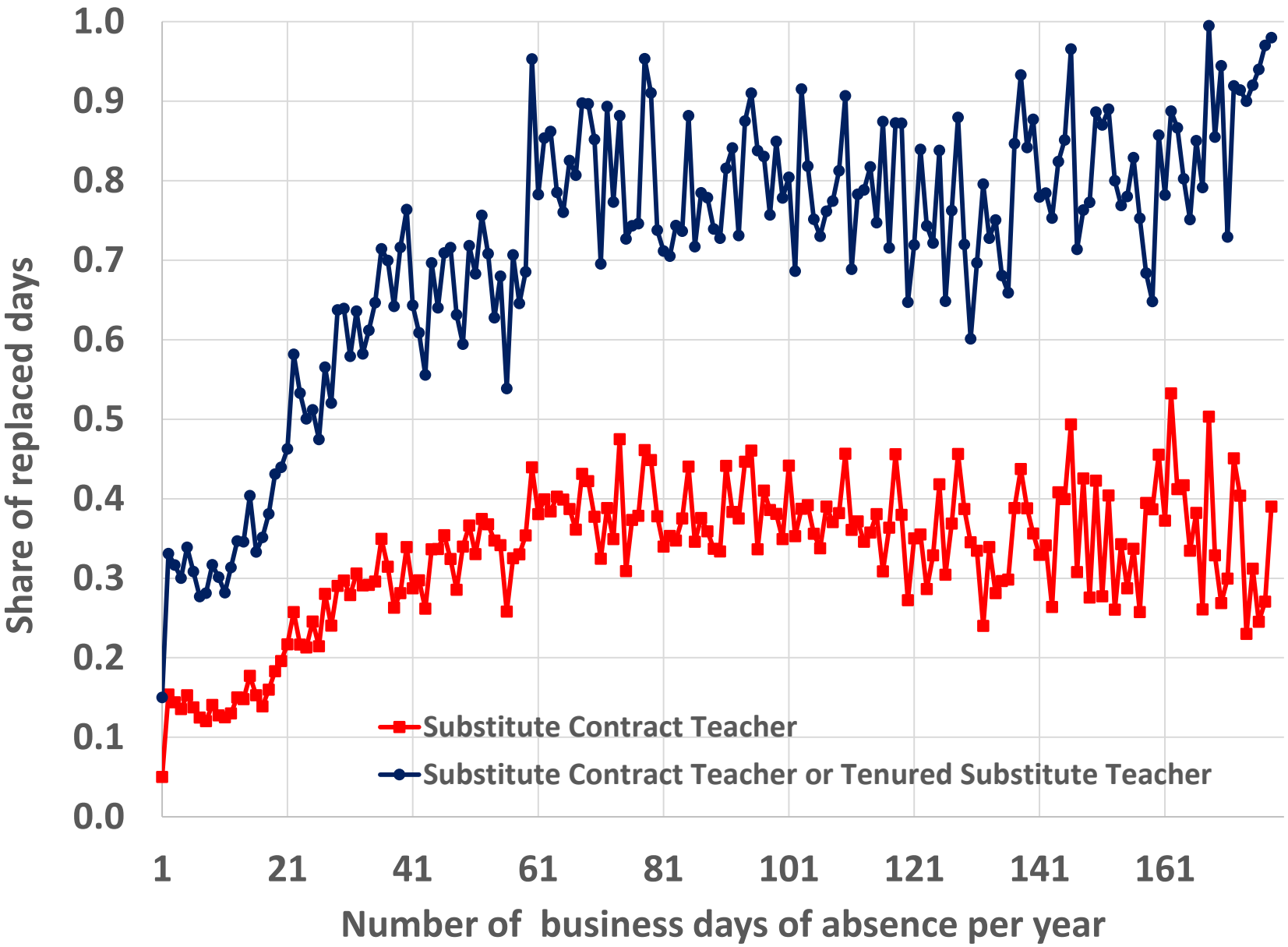
- **Teachers** :
  - national identifier, school, type of assignment(permanent,yearly, temporary), teaching subject, experience, age, gender
  - Teachers' absence and substitution spells : day, month and year of the spells, detailed cause of absence

- **Middle school students** :
  - encrypted national identifier, socio-demographic characteristics, school, grade and classroom attended
  - centralized externally graded test scores : DNB (end of 9th grade)

Cumulative Distribution of the Number of Days of Absence per Teacher-Year



Share of Replaced Days by Teacher-Year



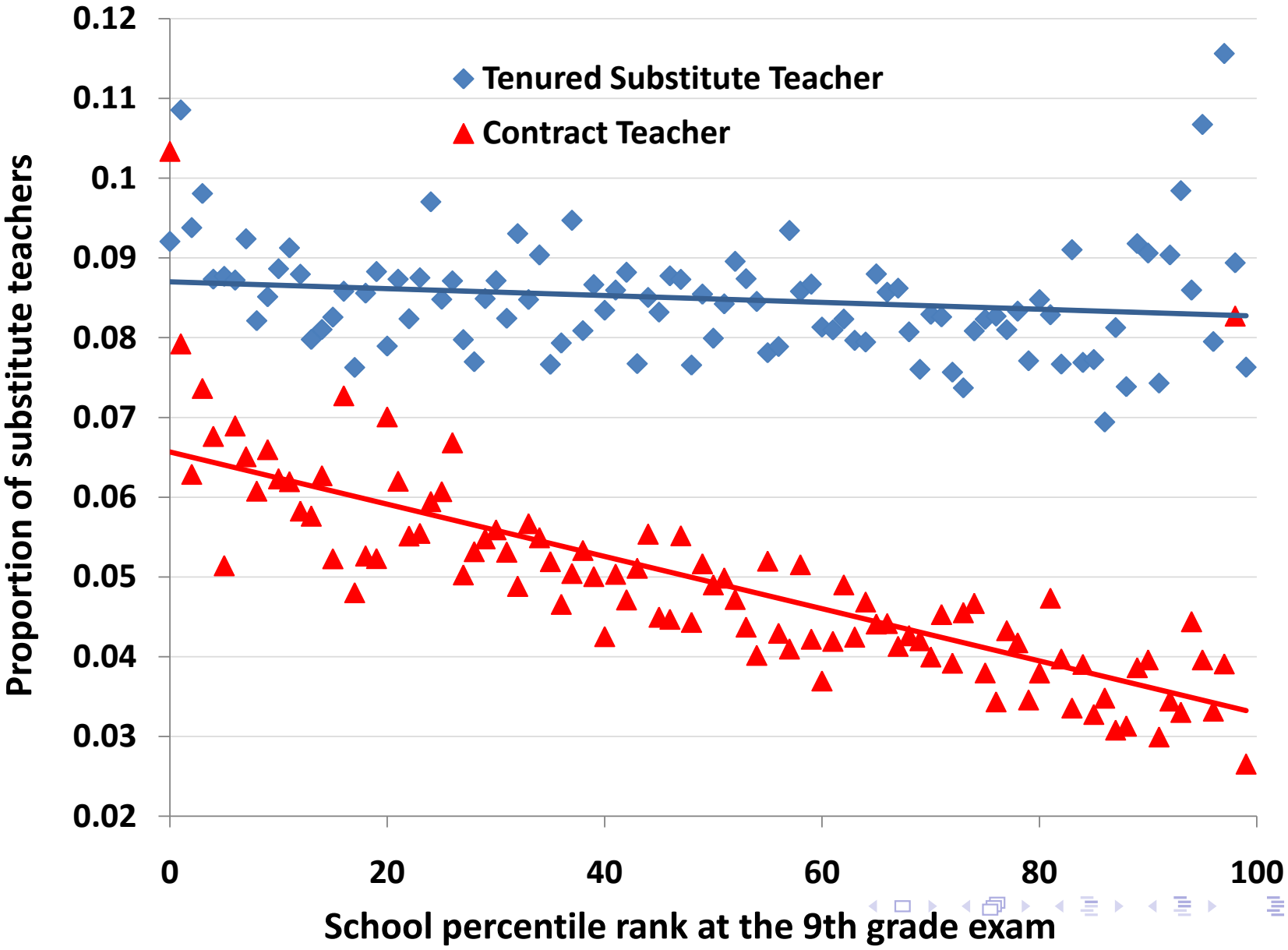
Substitute Teachers Characteristics

	Regular Teacher.	Tenured Sub.	Contract Teacher
A. **Demographics**			
Male	0.36 (0.48)	0.39 (0.49)	0.43 (0.50)
Age	43.8 (10.3)	39.0 (10.5)	37.9 (8.9)
Average Experience (in years)	14.1 (8.3)	10.0 (8.8)	4.6 (10.2)
A year or less of experience	0.02 (0.12)	0.13 (0.34)	0.32 (0.47)
B. **Certification**			
Agrégation	0.05 (0.23)	0.05(0.22)	–
CAPES	0.77 (0.42)	0.74 (0.44)	–
Other	0.17 (0.38)	0.21 (0.41)	–
C. **Evaluations**			
Classroom Observation Grade (/60)	46.82(5.99)	44.84 (6.39)	11.85 (9.59)
School Principal Grade (/100)	39.02(10.05)	39.15 (11.82)	13.86 (8.70)
D. **Absences**			
Nb of days of absence	6.58(16.15)	7.48(17.07)	5.53(11.83)
Nb of teachers	193,766	67,541	23,035

Contract Teacher Performances at the Certification Exam

	Contract Teachers Candidates		Other Candidates	
	Agreg.	CAPES	Agreg.	CAPES
A. Demographics				
Age (in years)	37.72 (7.75)	35.17 (7.68)	31.05 (8.32)	28.18 (6.65)
Male	0.53 (0.50)	0.39 (0.48)	0.46 (0.49)	0.35 (0.48)
B. Performance				
Passing Rate	0.03 (0.18)	0.16 (0.37)	0.15 (0.36)	0.33(0.47)
Written Part Grade (/20)	3.91 (2.52)	5.67 (3.14)	6.25 (3.61)	7.30 (3.69)
Oral Part Grade (/20)	7.00 (3.78)	7.30 (4.17)	8.09 (3.83)	8.50 (4.58)
Nb of obs	286	1,232	8,037	11,779

Proportion of Substitute Teachers by School Percentile Rank at the 9th grade exam



Teacher and Student Effects Model : Intuition

- **Standard approach** : exploit variations within teacher, across time in the number of days of absence with teacher fixed effect (Herrmann and Rockoff, 2012)
- **Main limitation of the standard approach** : shocks in student composition (reverse causality)
- **What I do** : also control for student fixed characteristics and ability with both student and teacher fixed effects

Teacher	Topic	Student	Year	Nb of days of teacher's abs.	Student's test score
Mr Dupont	Math	Caroline	2010	10	6
Mr Durant	French	Caroline	2010	0	10
Mr Dupont	Math	Henri	2011	5	8
Mr Durant	French	Henri	2011	1	9

Teacher and Student Fixed Effects Model

- **Identification assumption** : variations within teacher across year in the number of days of absence/number of days with substitute are not correlated with topic-specific student ability
- **Model** :

$$Y_{i,j,t} = A_{j,t}\beta + R_{j,t}\gamma + \theta_j + \theta_i + \theta_t + e_{i,j,t} \tag{1}$$

where :

- $Y_{i,j,t}$ student i test score with teacher j in year t ;
- $A_{j,t}$ the number of work day absence of teacher j in year t
- $R_{j,t}$ the number of replaced work days of teacher j in year t ;
- θ_i **student fixed-effect** ;
- θ_j **teacher fixed-effect**
- θ_t year fixed-effect.

Impact of days of absence/ replacement (in % of standard deviation) in 9th grade (2006-2015)

in % of a SD	(1)	(2)	(3)	(4)
Nb days of absence (in % of SD)	-0.291***	-0.101***	-0.086***	- 0.061***
	(0.009)	(0.009)	(0.008)	(0.002)
Nb of replaced days (in % of SD)	0.187***	0.012	0.007	0.000
	(0.010)	(0.010)	(0.009)	(0.000)
Av. nb of days of abs.	[9.91]	[9.91]	[9.91]	[9.91]
Av. nb of replaced days	[4.48]	[4.48]	[4.48]	[4.48]
Teacher Fixed effect	No	Yes	Yes	Yes
Student Fixed effect	No	No	No	Yes
Teacher experience & seniority	No	Yes	Yes	Yes
Student background*	No	No	Yes	No
Number of observations	457,676	457,676	457,676	14,874,904

*Student background : parents' occupation and financial aid status. All regressions include year x topic fixed effects except (1) and (4). (4) includes year fixed effects. Robust standard errors clustered by teacher.

Impact of days of absence/replacement (in % of standard deviation) in 9th grade (2006-2015) by type of substitute

in % of a SD	(1)	(2)	(3)	(4)
Nb days of absence	-0.273***	0.110***	-0.088***	- 0.065***
	(0.008)	(0.008)	(0.007)	(0.002)
Nb of replaced days x tenured sub.	0.344***	0.064***	0.052***	0.007***
	(0.018)	(0.001)	(0.002)	(0.002)
Nb of replaced days x contract sub.	0.228***	-0.003	-0.019***	-0.009***
	(0.019)	(0.002)	(0.001)	(0.002)
Av. nb of days of abs.	[9.91]	[9.91]	[9.91]	[9.91]
Av. nb replaced days tenured sub.	[2.33]	[2.33]	[2.33]	[2.33]
Av. nb replaced days contract sub.	[2.15]	[2.15]	[2.15]	[2.15]
Teacher fixed effect	No	Yes	Yes	Yes
Student fixed-effect	No	No	Yes	Yes
Teacher experience & seniority	No	Yes	Yes	Yes
Student background*	No	No	Yes	No
Number of observations	457,676	457,676	457,676	14,874,904

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Robustness Checks : Placebo Test Across Years

in % of a SD	**Current Year's Absences**	**Prior Year's Absences**
Nb days of absence	-0.061***	0.002
	(0.002)	(0.002)
Nb of replaced days	0.000	0.004
	(0.000)	(0.003)
Teacher Fixed effect	Yes	Yes
Student Fixed effect	Yes	Yes
Year Fixed Effect	Yes	Yes
Teacher experience & seniority	Yes	Yes
Nb of observations	6,629,630	6,629,630

Within Student, Across Topics Model

- **Idea** : exploit within student, across topics variations in substitute teacher assignment
- **Level of observation** : student x topic
- **Identification assumption** : substitute teachers are not assigned to students who are relatively less able in their topic
- **Model** :

$$A_{i,s,t} = 1_{i,s}\beta + \theta_i + \theta_s + \theta_t + e_{i,s,t} \tag{2}$$

where :

  - $A_{i,st}$ student i grade in subject s and year t ;
  - $1_{i,s}$: dummy equal to 1 if the teacher of subject s is a substitute teacher (tenured or contract)
  - θ_i **student fixed-effect** ;
  - θ_s subject s fixed-effect ;
  - θ_t year fixed-effect.

- **Coefficient of interest :** β

Effect of One Year Substitute Teacher in 9th grade

	(1)	(2)	(3)
Tenured Sub. Teacher	-.076***	-.052***	-.014***
	(.001)	(.002)	(.002)
Contract Teacher	-.224***	-.120***	-.089***
	(.002)	(.003)	(.004)
School Fixed Effect	No	Yes	No
Student Fixed Effect	No	No	Yes
Year x Topics Fixed Effect	No	No	Yes
Controls*	No	Yes	Yes
Nb of observations	13,901,866	13,901,866	13,901,866

* Controls : Teacher experience, seniority, certification. Robust standard errors clustered by student.

Preliminary Results : Less than a Year Absence

- Ten days of absence decrease student test scores by **0.65 % of a standard deviation**
- The number of replaced days on student test scores does not have any statistically significant compensating effect
- By type of substitute teacher :
  - One additional replaced day with a tenured substitute teacher (rather than no class) **mitigates 11 % of the marginal impact of absence**
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- Having a contract teacher for a year rather than a regular teacher decreases student test scores by **8.9 % of a standard deviation**
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Policy Implications

- **Short term absences** :
  - Whatever their type, substitute teachers seem unable to significantly mitigate the negative effect of short term absences on student achievement
  - Policy makers' focus should therefore be on reducing this type of absences
- **Long term absences** :
  - Contract substitute teachers significantly harm student achievement whereas tenured substitute teacher seem to do a good job
  - Give priority to tenured substitute teachers for long term assignment

Further Research

- Focus on maternity leave
- Instrument for absences : number of days of absence in the school (absence culture in the school, jacknife estimates) : Ost and Schiffman (2017)
- Instrument for substitute teachers : number of other teachers, in the same topic, absent at the same time, in the same replacement area
- Data on student violence