Estimating the effect of teacher pay on pupil attainment using boundary discontinuities

Ellen Greaves and Luke Sibieta
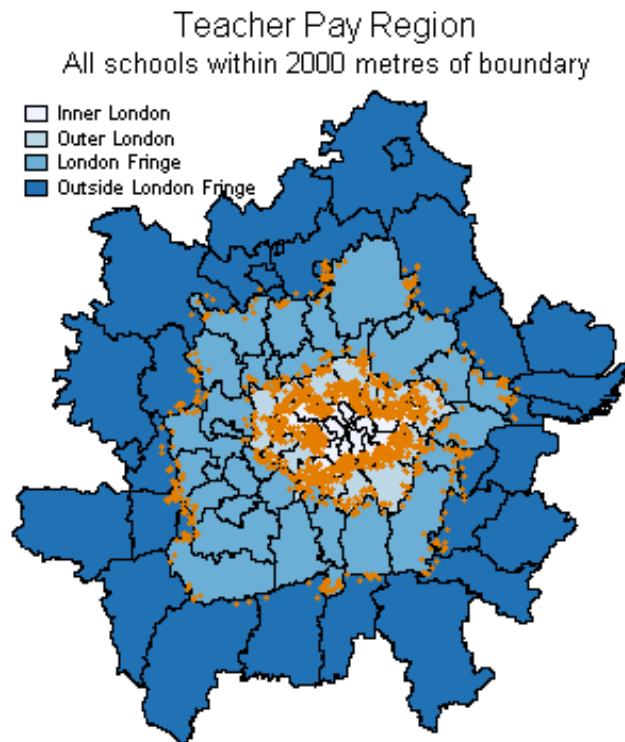
EEA, August 2014

Motivation

- Teacher effectiveness has a large impact on pupil attainment

- Teacher effectiveness is uncorrelated with many observable characteristics (Rockoff (2004); Rivkin et al (2005); Aaaronson et al (2007); Slater et al (2012))

- How can schools attract and recruit effective teachers?

  – Significant uncertainty about whether variations in pay and conditions can improve teacher effectiveness

  – Does higher teacher pay lead to higher teacher effectiveness?

    - Applications

    - Recruitment

    - Efficiency wages

Institute for
Fiscal Studies

Previous literature

- Difficult to find exogenous variation in teacher pay within countries -> identification is challenging
  - Determined by central or school district level agreements
  - Vary with experience
  - Vary with nature of school or local costs
- Hanushek (2006):
  - Little evidence of a positive effect of higher teacher pay
- Loeb and Page (2000):
  - Previous studies biased by exclusion of non-pecuniary factors
  - 10% increase in wages reduces drop-outs by 3-4%
- Britton and Propper (2012):
  - Exploit centralised wage bargaining and variation in outside wages in England
  - 10% increase in local wages depresses test scores by 0.1 standard deviations

Institute for
Fiscal Studies

Contribution

- Identify causal effect of higher teacher pay on pupil attainment using discontinuity in teacher pay around London area
  - Assumption: schools in close proximity to the discontinuity vary only in the level of teacher pay

Teacher Pay Region
All schools within 2000 metres of boundary

☐ Inner London
☐ Outer London
☐ London Fringe
■ Outside London Fringe

Institute for
Fiscal Studies

Contribution

- Identify causal effect of higher teacher pay on pupil attainment using discontinuity in teacher pay around London area

  - Assumption: schools in close proximity to the discontinuity vary only in the level of teacher pay

- Little evidence that sharp variation in teacher salaries of about 5% or £1,000 has a positive effect on age 11 test scores

- Able to rule out quantitatively small effects of 0.05 and 0.02 standard deviations in English and maths, respectively

- Implications:

  - Teachers' application decisions unaffected by variation in pay, or;

  - Schools might not be able to observe teacher quality amongst applicants

  - Competing for high-quality teachers using pay is unlikely to raise teacher effectiveness

  - Role of pay might be to drive initial occupation choices, rather than sorting across schools

Institute for
Fiscal Studies

Outline

- Institutional context

- Empirical methodology

- Results

- Conclusions

Institute for
Fiscal Studies

Institutional context

- School system

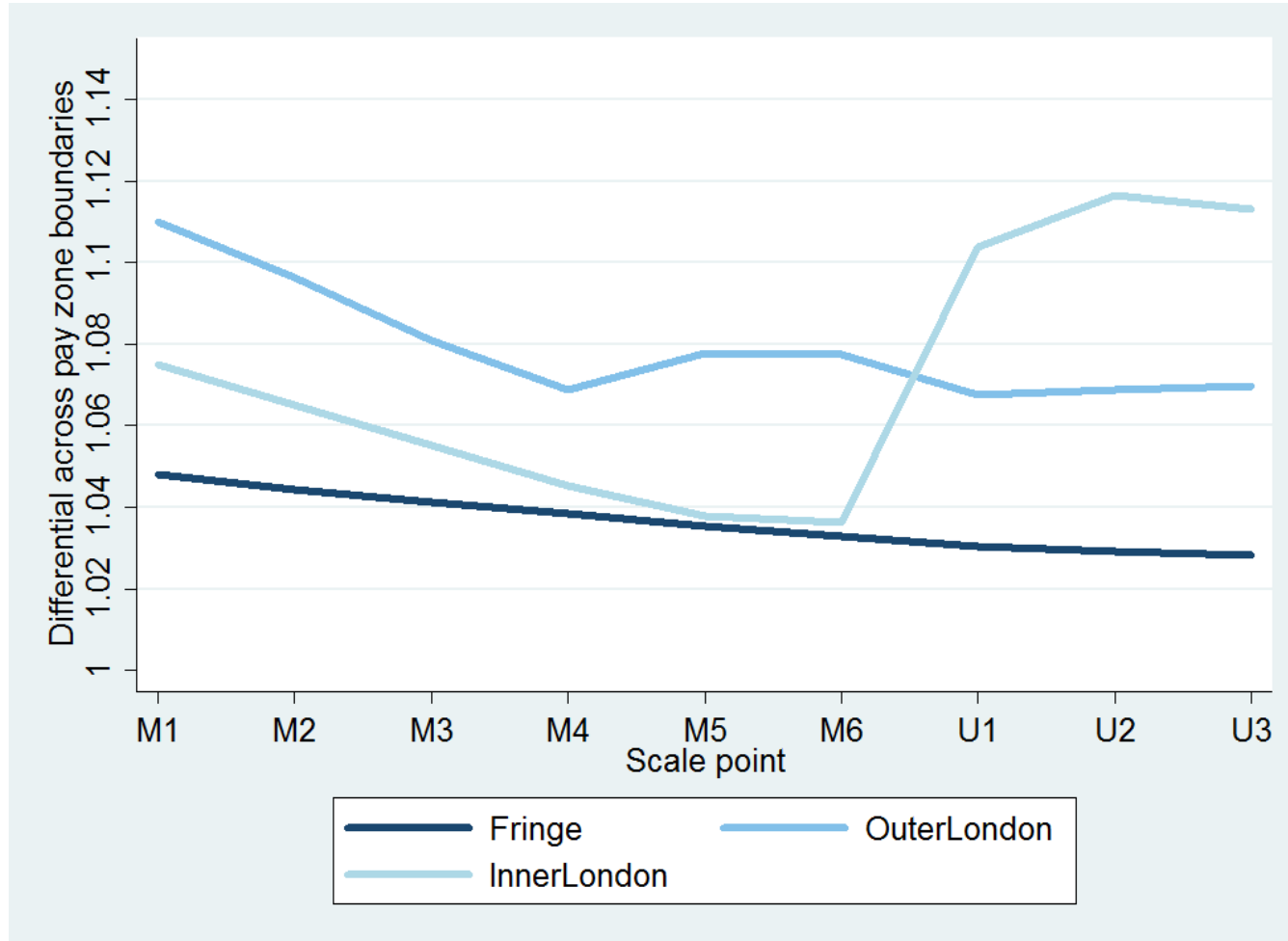- Teacher labour market

- School funding

Institutional context

- School system
  - Focus on primary schools (ages 4-11)
  - Key Stage 2 tests at age 11 – English and Maths
  - Tests are externally set and marked
- Teacher labour market
- School funding

Institute for
Fiscal Studies

Institutional context

- School system

- Teacher labour market

  - Schools post vacancies and teachers apply to individual schools

  - National pay and conditions

  - Teacher pay scales (M1-6, U1-3)

  - Higher pay at each scale in the London area to reflect higher cost of living

- School funding

Institute for
Fiscal Studies

Pay Differential across Neighbouring Pay Zones

Institutional context

- School system

- Teacher labour market

- School funding

  – Central government provides grants to local authorities (to reflect need/costs)

  – Local authorities allocate funds to schools using own formulae (specific weight for number of pupils and pupil characteristics)

Institute for
Fiscal Studies

Empirical methodology

- Pupil attainment: $Y_i = f\left(X_{pi}, X_{ai}, S_i, T_i, \varepsilon_i\right)$

  - Where X_{pi} represents pupil characteristics (such as socio-economic background)

  - Where X_{ai} represents neighbourhood characteristics (such as local deprivation)

  - Where S_i represents school attributes (such as resources)

  - Where T_i represents teacher effectiveness

  - Where ε_i represents all unobservable influences on pupil attainment (such as ability)

- Can't measure T_i directly: not currently possible to link teachers to pupils in England

- -> Compare mean outcomes across schools

Institute for
Fiscal Studies

Empirical methodology

$$\overline{Y}_H - \overline{Y}_L = \beta_p \left(\overline{X}_{pH} - \overline{X}_{pL} \right) + \beta_a \left(\overline{X}_{aH} - \overline{X}_{aL} \right) + \beta_s \left(\overline{S}_H - \overline{S}_L \right) + \beta_T \left(\overline{T}_H - \overline{T}_L \right) + \left(\overline{\varepsilon}_H - \overline{\varepsilon}_L \right)$$

0   0   0   0

- *H* denotes high pay side of boundary
- *L* denotes low pay side of boundary
- Within close proximity of the boundary:
  - Average pupil characteristics should be equal
  - Average neighbourhood characteristics should be equal
  - Average school attributes should be equal (aside from additional funding to compensate for higher teacher salaries)
  - Average unobservable characteristics should be equal

Institute for
Fiscal Studies

Empirical methodology

$$\overline{Y}_H - \overline{Y}_L = \beta_p \left(\overline{X}_{pH} - \overline{X}_{pL} \right) + \beta_a \left(\overline{X}_{aH} - \overline{X}_{aL} \right) + \beta_s \left(\overline{S}_H - \overline{S}_L \right) + \beta_T \left(\overline{T}_H - \overline{T}_L \right) + \left(\overline{\varepsilon}_H - \overline{\varepsilon}_L \right)$$

0   0   0   0

- *H* denotes high pay side of boundary

- *L* denotes low pay side of boundary

- Within close proximity of the boundary:

  - Average pupil characteristics should be equal

  - Average neighbourhood characteristics should be equal

  - Average school attributes should be equal (aside from additional funding to compensate for higher teacher salaries)

  - Average unobservable characteristics should be equal

- -> Difference in pupil attainment represents the difference in teacher effectiveness driven by the exogenous difference in teacher pay across the boundary

- -> Identification relies on continuity assumption

Institute for
Fiscal Studies

Empirical methodology

- Compare school-level outcomes within 2 km of the London Fringe boundary

  – Vary distance as robustness check

  – Estimate raw and conditional differences

  – Check balance of observable characteristics to inform continuity assumption

Institute for
Fiscal Studies

Data

- **National Pupil Database (2005-06 to 2010-11)**
  - Administrative data for all state-school pupils in England
  - Age 11 test results, pupil characteristics, school characteristics
  - Exclude 2009-10 data: boycott of national tests
- **LEASIS/Edubase**
  - School characteristics (including precise location)
- **School Workforce Census**
  - Teacher pay, grade and characteristics
- **Section 251**
  - Income and expenditure
- **School Teachers Pay and Conditions**
  - Teacher Pay Region

Data: continuity assumption (within 2km)

School characteristics	High pay area ("Fringe London")	Low pay area ("Rest of England")	Difference
Prop. FSM	0.08 (0.07)	0.08 (0.08)	0
Prop. SEN (no s.)	0.21 (0.10)	0.21 (0.11)	0
Prop. SEN (s.)	0.02 (0.02)	0.02 (0.02)	0.00***
Prop. EAL	0.07 (0.11)	0.07 (0.10)	0
Prop. non-white	0.16 (0.12)	0.16 (0.13)	0
FTE pupils	259.8 (119.8)	250.2 (110.2)	9.6
IMD rank	0.73 (0.17)	0.70 (0.17)	0.03**
IDACI rank	0.66 (0.17)	0.65 (0.18)	0.01
Likelihood ratio test			0.00
Number of schools	120	136	

Institute for Fiscal Studies

Outcomes and theoretical predictions

- Teacher salaries

- Funding per pupil

- Actual resources

- Pupil attainment

Institute for
Fiscal Studies

Outcomes and theoretical predictions

- Teacher salaries
  - Expect positive effect in line with statutory salary scale differences
  - But, schools have freedom to smooth the difference using other pay freedoms
- Funding per pupil
- Actual resources
- Pupil attainment

Outcomes and theoretical predictions

- Teacher salaries

- Funding per pupil

  – Expect higher funding levels to compensate for higher statutory salaries

  – Teacher pay accounts for about 50% of schools budget

  – -> Expect funding differential equal to about 50% of salary differential

  – -> Additional 2-3% funding

- Actual resources

- Pupil attainment

Outcomes and theoretical predictions

- Teacher salaries

- Funding per pupil

- Actual resources

  – No difference if funding differential allows schools to purchase same bundle

  – Lower (higher) staff to pupil ratios if funding differential is over (under) generous

- Pupil attainment

Institute for
Fiscal Studies

Outcomes and theoretical predictions

- Teacher salaries

- Funding per pupil

- Actual resources

- Pupil attainment

  - **1. Selection:**

  - *Positive effect* if higher salaries attracts more high quality teachers and potential quality is observable among applicants

  - *Negative effect* if potential quality is unobservable among applicants and intrinsic motivation is correlated with quality (Delfgauww and Dur, 2007)

  - **2. Efficiency wage:**

  - *Positive effect* if higher effort levels among existing teachers and effort influences effectiveness

Institute for
Fiscal Studies

Results: teacher salaries

School characteristics	(1)	(2)	(3)	(4)
Teacher salary (£)	1311.0** (473.8)	1288.7** (447.8)	1009.5* (441.5)	696.4 (416.5)
Spinepoint	0.099 (0.17)	0.061 (0.15)	0.045 (0.15)	-0.001 (0.14)
Teacher characteristics	No	Yes	Yes	Yes
Additional responsibilities	No	No	Yes	Yes
School characteristics	No	No	No	Yes
Observations	3,097	3,097	3,097	3,097
Number of schools	247	247	247	247

➢ Little evidence of pay smoothing on the low pay side

➢ Difference in teacher salary is slightly higher than expected before and after controlling for teacher characteristics (age, sage squared, gender, tenure, tenure squared)

➢ Some of the higher pay is related to additional responsibilities: controlling for additional responsibilities gives an estimate of the expected sign

Institute for Fiscal Studies

Results: funding per pupil and school resources

School characteristics	OLS: without covariates	OLS: with covariates	FILM	Propensity score matching
Funding per pupil (log)	0.004 (0.02)	-0.009 (0.01)	-0.012 (0.01)	-0.016 (0.01)
Pupil:Teacher Ratio	-0.148 (0.34)	-0.067 (0.24)	-0.092 (0.23)	-0.035 (0.19)
Pupil:Assistant Ratio	18.20 (13.65)	12.46 (12.03)	14.08 (12.39)	17.99 (10.76)
Observations	1,563	1,563	1,563	1,563
Number of schools	321	321	321	321

➤ Little evidence of sufficient increase in funding to compensate for higher teacher salaries (differences in salary scales of 4-5% imply a school would need an additional 2-3% increase in funding to afford the same bundle of resources)

➤ But resources are not significantly affected

Institute for Fiscal Studies

Results: pupil attainment

School characteristics	OLS: without covariates	OLS: with covariates	FILM	Propensity score matching
KS2 English (std)	0.016 (0.04)	0.018 (0.02)	0.015 (0.02)	0.006 (0.02)
KS2 Maths (std)	-0.016 (0.04)	-0.016 (0.02)	-0.019 (0.02)	-0.028 (0.02)
Observations	1,563	1,563	1,563	1,563
Number of schools	321	321	321	321

➢ Little evidence of any positive impact of the higher teacher pay area

➢ Small, positive and statistically insignificant effect for English across all specifications

➢ Small, negative and statistically insignificant effect for maths across all specifications

➢ Rule out small effects (0.05 and 0.02 standard deviations, respectively)

➢ Higher teacher salaries are not related to higher pupil attainment
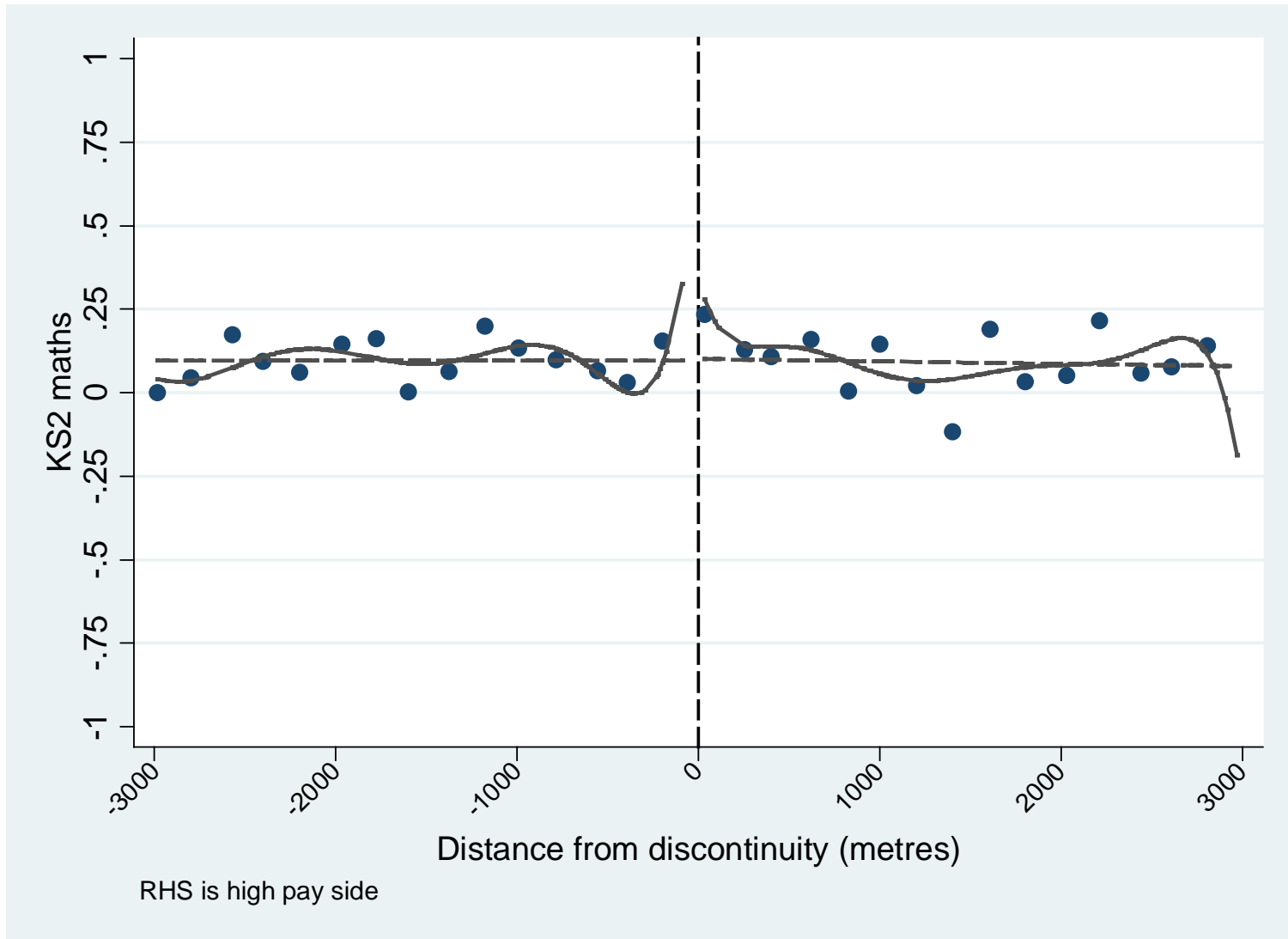
Institute for Fiscal Studies

Summary

- Continuity across discontinuities for differences in observable characteristics

- "High pay side" doesn't receive sufficiently high funding to compensate for higher teacher salaries, but there are no evident differences in school resources

- Discontinuity in salary scales translates into differences in teacher pay

- No significant differences in pupil attainment in maths and English - can rule out small positive effects

Institute for
Fiscal Studies

Conclusions and policy implications

- Little evidence of an effect of teacher pay differentials on pupil attainment

- Effects are slightly smaller than those found in Britton and Propper (2012)
  - Primary vs Secondary Schools
  - Different identification strategies
  - Different sorting mechanisms

- Using pay differentials to compete for high-quality teachers is unlikely to be an effective strategy for schools
  - Greater importance attached to non-pecuniary factors?
  - Can schools observe the most effective teachers among applicants?

- More potentially effective strategies to improve teacher effective include providing more information on applicants or performance-related pay

Institute for
Fiscal Studies

Additional slides

Relationship between distance to boundary and pupil outcomes essentially linear with noise

RHS is high pay side

Institute for
Fiscal Studies

Growth in Pay scales by Area 2005-2010

Institute for
Fiscal Studies