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Does Wage Regulation Harm Kids? Evidence from English Schools

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Keywords: Teacher Wages, Centralised Pay Regulation, School Performance, School Value Added

JEL Classification: I2, J3, J4

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1 Introduction

The importance of education means that teacher productivity is a large concern for government. While pay for performance for teachers has received considerable attention from policy makers and economists (Hanushek (1986); Umansky (2005), and Podgursky and Springer (2007) provide reviews), one feature of teacher remuneration that has received less attention is the effect of collective bargaining. The combination of a strong degree of unionization on the employee side and public employers means that collective bargaining is a fixture in many education systems. For example, in the USA, as of 1988, all but seven states had passed a law either allowing for the right of teachers to bargain collectively or explicitly requiring districts to bargain with teachers unions (Lovenheim (2009)). Wages are also centrally negotiated between the state or national government and the teaching unions in many European countries (Galgczi and Glassner (2008)).

A frequent corollary of collective bargaining is that pay is mandated to be the same across large geographical areas which include heterogeneous labour markets. When the outside market wage is high the regulated wage acts as a pay ceiling and we would expect this to cause difficulties in recruitment and retention, especially of higher quality workers, which in turn should lead to lower service quality. The contribution of this paper is to examine this simple economic intuition and to show that centralized pay regulation of teachers has a negative impact on the learning of pupils.

Our design exploits the centralized pay setting of over 200,000 teachers in the UK public (state) school system. In the UK pay for teachers is set by a central review body that sets pay scales in which there is very limited regional variation. The variation that exists does not fully reflect the wages differentials in the external labour markets in which the staff are employed. Regional pay differences are considerable in the UK private sector even after controlling for human capital characteristics and other factors. [1] We would therefore expect to see differences between inside and outside wages reflected in staffing difficulties that manifest themselves in the lower performance of schools operating in high outside wage labour markets.

Our design also exploits the common national testing system used for all pupils in English state schools. Pupils take the same nationally graded exams at ages 11 on entry into secondary schools (equivalent to US middle and high schools) and at the end of compulsory education at age 16. This means we can examine the same measure of attainment across all state schools in England and a (common) measure of value added. The latter controls for time constant pupil, family and neighbourhood characteristics that may affect levels of attainment independently of teacher effort, so we can focus on the effect of wages net of these factors.

We find a ten percent increase in the local average outside wage results in an average loss of one exam grade per pupil in the high-stakes end of secondary school examinations. This is worth 2% of the overall average score in these examinations. The results are robust to a wide range of specification tests. In addition, we address concerns about potential endogeneity of wages to performance and examine other possible parental and pupil channels through which the outside

[1] See Bulman (2002). As in the United States (e.g. Borjas (2002)) the cross sectional dispersion of UK public sector pay is much lower than in the private sector (e.g. Disney and Gosling (1998)).

wage may affect pupils performance.

Our paper is connected to several literatures. There is a large literature on the impact of teacher pay. One branch investigates the effect of teacher salaries on school performance. Although initial evidence on this was mixed (for example Hanushek (1986) highlights that only nine out of sixty teacher salary studies found a positive effect of teacher wages on school performance), work since then has mostly counteracted this. Loeb and Page (2000) find teacher wages to be a significant determinant of outcomes, estimating that a 10% increase in teacher wages would reduce dropout rates in the US by between 3 and 6%, while Dolton et al (2011) finds both relative and absolute levels of teacher salaries exert an important influence on pupil performance, using panel data on 39 countries. A second branch of this literature examines the impact of teacher pay on recruitment of higher quality teachers (for example Murnane and Olsen (1990), Dolton (2006), Figlio (2002) and Clotfelter et al. (2008)), and a third shows that teacher quality is important for student attainment (for example Rivkin et al (2005), and Goldhaber (2002)). There is also a growing body of work investigating the impact of performance related pay. Whilst again there is some mixed evidence, the general consensus appears to be that performance pay for teachers does improve student attainment in a variety of settings. Examples include Lavy (2009) in Isreal, Muralidharan and Sundararaman (2009) in India, Jackson (2010) in Texas, Bettinger (2010) in Ohio and Atkinson et al (2004) in England.[2] In highlighting a relationship between local labour market wages and school performance, we provide further evidence favoring the argument that teacher wages are important for school performance.[3]

More generally, labour economists have long been interested in the impact of labour market changes on firm performance. Theories of efficiency wages, for example, suggest that improvements in the labour market outside the firms boundaries could lead to decreased productivity within a firm because there may be more shirking (Shapiro and Stiglitz (1984)), a loss of high quality workers (Weiss (1980)) or perceptions of inequity (e.g. Akerlof (1982); Mas (2006)). It is difficult to test these ideas in an unregulated labour market. Where pay is set by regulation, however, there is a wedge between inside and outside wages that enables identification of the impact of external labour markets on firm outcomes. So we can effectively use regulation to generate exogenous variation in factor prices.

In this design, two papers are close antecedents to ours. The first is Cappelli and Chauvin (1991) who show that higher outside wages increase shirking (as measured by the dismissal rate) in a US auto manufacturer. Like our paper, the authors exploit the fact that the union contract stipulates the same pay rates across diverse metropolitan areas. Unlike our paper, Cappelli and Chauvin exploit a private agreement between a union and a firm, which is likely to be less sub-optimal than a voluntary agreement between a government and a national wide union. In addition, Cappelli and

[2]Some of these effects are large. For example, Bettinger finds the positive effects of cash incentives for teachers on achievement to be 250 times what would be predicted if the school district had spent the same amount on class size reduction (based on the results of project STAR - see for example Krueger and Whitmore (2001)).

[3]Barr and Zeitlin (2010) find that teacher absenteeism in Uganda was higher in areas where the wages of the parents of the children they were teaching were higher, suggesting the wage of teachers relative to other workers is important.

Chauvin have a cross section of 78 plants, whereas we have a much larger panel of around 3000 schools. The second - and closest - paper is Propper and Van Reenen (2010), who examine the impact of centralized wage regulation for nurses on death rates following in emergency admissions for heart attacks to English hospitals between 1996 and 2005. They find that the aggregate death rate rises due to the regulation and that removal of centralized wage setting would have positive welfare consequences. Our paper complements theirs by focusing on another aspect of state activity: education in the 3000 secondary schools that educate around 3 million of Englands children per annum.

The remainder of the paper is as follows. Section 2 outlines the institutional background of education in the UK, Section 3 provides information on the data used and Section 4 discusses the methodology. The results and a range of robustness checks are given in Section 5. Section 6 studies potential mechanisms through which the outside wage could operate. Section 7 investigates the possibility of heterogeneity in the relationship between outside wages and school performance and provides a simple cost benefit analysis of the effect of removing centralized pay regulation. Section 8 concludes.

2 Institutional Background

Education in England is compulsory between the ages of five and sixteen. Children can be educated privately or through the state system, but the state system dominates. In 2007 approximately three million young people (around 84% of eleven to sixteen year olds) were attending state secondary schools. Pupils in England in the state system must attend primary school from ages five to eleven and secondary school from the ages of eleven to sixteen. Age sixteen is the end of compulsory schooling. Pupils can then stay on for a further 2 years and gain qualifications which allow them to undertake University level education. In each secondary school there are five (or seven if the school provides education up to 18) separate age cohorts within the school at any one time.

Pupils take nationally set exams at four points during their ages of compulsory school attendance. At primary school these are Key Stage 1 (KS1) at age 7 and Key Stage 2 (KS2), in Mathematics, English and Science, at age 11 (the age of exit). In secondary schools these are Key Stage 3 (KS3) exams at age 14 in Maths, English and Science and Key Stage 4 (KS4) examinations in multiple subjects (typically between eight and twelve) at the end of compulsory schooling at age 16. We focus on KS4 (GCSE) examinations. These are high stakes examinations: for pupils they determine progress into education beyond the age of 16 (a minimum of five pass grades required to continue on to education beyond age sixteen), and for schools, they are used to evaluate school performance as the KS4 results are published and widely disseminated annually at school level. More widely, KS4 results are used by parents to choose schools for their children at age 11, by the media to create school 'league tables' and by local and central government to identify 'failing schools'.[4] As

[4]The KS3 exams are relatively unimportant; pupils cannot leave schools at this age and generally are already ability streamed (tracked) prior to KS3 exams, so KS3 performance has a relatively minor effect on pupils' progress through school.

KS2 examinations are taken prior to entry to secondary school, they can be used as an exogenous control for quality of pupil intake. Thus we can examine a measure of the value added to pupils in each year by each secondary school.[5]

2.1 Teacher Pay in England

Teacher wages are set by Local Education Authorities (LEAs) based on guidelines issued by the central Government Department for Education.[6] Despite the existence of four pay bands ('Inner London', 'Outer London', 'The Fringe' and 'The rest of England'), teacher wages have exhibited very little regional variation relative to private sector wages since the early 1970s. For example, the average teacher wage differential between the North East of England and Inner London is approximately 9%, while the equivalent private sector wage differential is larger than 30%.[7] Since its formation in the 1990's, the School Teacher Review Body (STRB), an advisory board which comments on teacher conditions and pay, has frequently argued that the Department for Education should be doing more to encourage locally flexible wages. Although an increasing amount of discretion over wages has been granted to LEAs, they have almost entirely failed to utilize the option. This is likely to be due, in part, to the fact that local authorities face historically strong national teaching unions (Zabalza (1971)).

In addition, there is very little scope for schools to provide differential non-pecuniary benefits for teachers - there is no variation in holidays and contact hours are generally fixed. There is also little evidence of schools in high wage areas recruiting higher numbers of teachers to overcome poor quality of staff or over-promoting teachers at younger ages to avoid the restrictions on pay.[8]

There are a number of mechanisms through which an invariant teacher wage could affect school performance. First, problems may arise in recruitment and retention. Elliott (2009) finds a negative relationship between relative teacher wages and posted Local Authority level teacher vacancies in England. Ransom and Sims (2000) find a high wage elasticity of teacher supply in the US. Second, public sector wage increases have been shown to improve the qualifications of new public sector workers (Nickell and Quintini (2002)), suggesting the effect may not be seen just through vacancies, but also through reduced teacher quality. Teacher quality is important for performance (Barrow and Rouse (2005); Rockoff (2004); Benton et al. (2003)) and teachers have been shown to be adversely affected by lower quality colleagues and by high turnover rates (Ronfeldt, Lankford, Loeb and Wyckoff (2011)). Finally the nature of teaching in England means a large proportion of the work is discretionary (time spent lesson planning, engagement in after-school programs, time invested worrying about particular children), so there is scope for reductions in effort in response

[5]Selection based on KS2 results or its correlates is not permitted in almost all state secondary schools in England. A minority of schools are allowed some selection of pupils; these types of school are excluded from the analysis in a robustness check.

[6]LEAs are coterminous with the primary unit of local government, the Local Authority (LA). In what follows we use the term LEA when discussing education issues and LA when discussing data available at this level.

[7]Authors' own calculation from LFS data outlined in Appendix. Our estimates of the teacher wage differential corresponds closely with School Teacher Review Body data on teacher wages.

[8]Source: STRB annual report, 2010

to lower relative wages.

Dolton (1990) finds that wages are an important factor in recruiting good teachers but existing research on the effect of the teacher wage structure in England is limited. Two previous studies of school performance suggest that relative pay is important but neither test this hypothesis. Gordon and Monastiriotis (2006) investigate neighbourhood and regional effects on education performance and conclude that schools from some of the most affluent areas perform worst relative to expectation. They attribute this to crowding out of public sector activity in affluent areas. Zabalza et al (1971) examine English secondary schools in the 1960s and find fewer qualified teachers and higher turnover rates in London compared to the rest of the country and attribute this to the poor relative wages in London.

2.2 How centralized pay may affect school performance

We follow Hall et al (2008) and propose a simple dual-region model of the English market for teachers. In this market, 'The North' has low living costs and fewer outside options relative to 'The South'. Even when controlling for worker composition, the local private sector wage is therefore lower in the North. Because of these factors, for each given wage, teacher supply is higher in the North than in the South. An ideal pay structure would therefore allow differential wages in each region to equalize supply and demand. As shown in Figure 1, setting the centrally regulated wage to be constant across the two regions at W^C, even if on average the regulated wage is an equilibrium, a wedge exists between it and the equilibrium wage at the regional level. In this model the regulated wage acts as a pay ceiling in the South, which may result in difficulties with recruitment, retention and motivation of teachers, resulting in reduced school quality.

This model presents the case of an invariant regulated wage across regions. This is not the case in England where, as noted above, there is some wage variation across broadly defined regions. However, as can be seen from Figure 1, unless the regional variation is such that the teacher wage in the South is set equal to W^S, and the teacher wage in the North is set equal to W^N, the nature of the problem persists; disequilibria in local markets will remain, affecting teacher supply in certain regions. Based on the lack of variation that we observe in teacher wages compared with private sector wages (and indeed the focus of the STRB on the issue of lack of across school variation), it is highly unlikely that the regional variation in England goes far enough.

This model highlights the possibility of insufficient supply in high wage areas, but is silent on alternative options for teachers, heterogeneity in skill levels, and the effort of teachers. Figure 1 would be unchanged if it were referring to the supply of quality teachers, or indeed the supply of effort of teachers; in either case there would remain a shortage in the South as a consequence of the invariant wage.[9] This highlights that the effect of an invariant wage on school performance in high wage areas could work through a number of mechanisms. High ability teachers might decide to leave the profession, move within the profession to a region where their relative wage is higher,

[9]Propper and Van Reenen (2010) present a more complex two sector, two skills model in which individuals can move sector or move region. An extension to this would be to include effort in the model.

or be deterred from entering teaching in the first place (either before or after completing teacher training). Finally, existing teachers might put in lower effort. These factors are all on the causal path between the invariant wage and school performance. Here we focus on identifying whether there is a casual effect.[10]

3 Data

To undertake our analysis we match data on school performance with data on local wages. School performance data are derived from the Pupil Level Annual School Census (PLASC), a panel dataset of 3285 secondary schools in England. We use data from 2002 to 2008 inclusive.[11] The local wage data are from the Annual Survey of Hours and Earnings (ASHE) dataset, a 1% sample of all employees in Great Britain, covering approximately 300,000 workers per year and provides wage data at Local Authority level for the years 1997 through 2007. The ASHE wage data are based on a survey taken in April of each year.

3.1 School Value Added

We define value added as the average pupil attainment in KS4 exams controlling for the average attainment of the same cohort pupils immediately before they enter secondary school. This prior attainment is measured by KS2 exam scores.[12] Pupils can take up any number of KS4 exams, with a minimum of one and a conventional maximum of around fourteen,[13] in a range of subjects including Mathematics, English language, English literature, Science subjects, and History. KS4 exams are graded from A* to G, and these grades are translated into points, such that an A* is worth eight points, an A is worth seven, a B is worth six, and so on. KS2 exams are graded from 2 to 5, and are taken in only Math, English and Science.[14] The PLASC dataset also includes an official measure of value added which we examine in the robustness section.

3.2 Outside Wages

The 'outside wage' is intended to measure the alternative private sector wage which teachers would use as a benchmark to measure the competitiveness of their own wages. We define the outside

[10] With the exception of investigating vacancy rates, we are unable to disentangle these factors due to data restrictions.

[11] 2002 is the first year for which there is data for our analysis. The PLASC dataset began in 2002. It was preceded by the Annual School Census (ASC) which contains mean school level KS4 scores but does not contain KS2 scores for the pupils in the school as KS2s are taken before entry into secondary school. This means school level value added cannot be observed before 2002.

[12] There are more primary schools than secondary schools so in one secondary school pupils will be from a number of different primary schools.

[13] There is no official maximum, although taking more than fourteen is rare. The regulator publishes KS4 results from all exams and, to facilitate comparison between schools, a capped KS4 score which uses point scores from the best eight exam results as schools allow their pupils to take different numbers of GCSEs. We use the full scores here but examine the capped measure in robustness checks in Section 5.

[14] Results are re-scaled in the PLASC dataset. See Value Added Technical information on the Department for Education website for information.

wage for each school as the average wage of all Local Authorities (LA) whose headquarters - i.e. their main office - lie within a 30km radius of the school. This circle around the school represents a 'travel to work' area (TTWA), in which teachers at the school could seek alternative employment.[15] In some areas, there are as many as 45 LAs within this radius, whilst in many others there is just one. For schools where there is not a headquarters of a LA within the 30km radius (or the wage data is missing for the LAs within that range) the nearest LA with wage data is allocated to a school, provided that LA is within 60km of the school. If the nearest LA with wage data is outside that distance, the school is excluded from our analysis.[16]

The ASHE dataset provides average wages for each LA. However, area wages may differ because of labour supply composition rather than because of the level of wages for a particular type of worker. To control for this we follow Propper and Van Reenen (2010) and correct wages for differences in workforce composition (gender and education) between LAs (see also Elliott, 2010). For our main specification regressions we use the log of the population-type corrected full time male non-manual wages. We examine the use of other wages in robustness tests.

3.3 Controls

In addition to the KS2 scores of the cohort of pupils taking KS4 examinations, we further control for school intake to allow for differences in the difficulties of educating pupils across schools. The PLASC dataset contains final-year (age 16) cohort-level statistics on the ethnic composition of pupils,[17] the proportion of special needs students, the proportion of male students, and the proportion of low family income students.[18] We also have the same data at school-level (i.e. in addition to at cohort level) plus expenditure per pupil at school level. At local authority level we have data on population density, the proportion of children from the area who attend private schools, and the proportion sent to selective schools.[19] We use all these controls to allow for the possibility that certain types of students may be more or less easy to 'add value' to. For example, pupils who are first generation non-English speaking immigrants before their KS2 examinations might be particularly easy to add value to, as their KS2 results would have been hindered by poor English skills which would likely have improved independently of the quality of the school. School level data on the type of pupil in the school is included in addition to the cohort level data to allow for the possibility that a cohort's (age group) performance could be affected by the composition of students from other cohorts within the school.

[15] See also Propper and van Reenen (2010).

[16] The small distances in England mean only nine schools are dropped from the sample using this approach. In robustness tests below we examine the impact of using different radii to define the TTWA.

[17] Proportions of Black, Chinese, Bangladeshi, Indian, White students and the proportion of students with English as a first language

[18] Low income is measured by eligibility for free school meals which are provided to students from families who are in receipt of social security

[19] Selective schools (which are state schools) admit children based on ability or other criteria such as religious affiliation. Such schools are excluded from the sample. Controls for private schools allows us to control for the fact that such schools may have an effect on state schools nearby: see for example, Gordon and Monastiriotis (2006) Figlio and Hart (2010) and Chan and McMillan (2009).

3.4 Summary Statistics

Summary statistics of all variables are in Table A2 in the Appendix. The table shows the range of KS4 points across school is large, with a minimum score of zero and a maximum of just under 100. The mean is just under 44. While the between variance is higher than the within school variance, the within variance is still around half the between.[20] KS2 scores are in different units to KS4 and have a mean of just under 27. Again the within variance is relatively large as a proportion of the total. The key explanatory variable of interest, the log of the 'outside wage' corrected for local workforce composition, has a school-level mean of 7.36, which equates to an average salary of just over £33000 per year. The within group variation is also large relative to the total. Table A2 also presents the outside wage averaged for each school over a five year period. We use this average wage in our main specification (see Section 4).

As an initial look at the patterns in the data we present cross sectional estimates for each year of our data to examine whether there is any relationship between outside wages and school value added. Table 1 shows the estimated effect of the (log of the) outside wage on school value for 2002 to 2008. The dependent variable is mean school-level KS4 point score with controls for mean KS2 point score and local authorities dummies.[21] The outside wage is lagged by one year, as teacher performance is unlikely to respond immediately to wage shocks and student performance is unlikely to respond immediately to changes in teacher performance. The coefficients represent the estimated reduction in average GCSE points per pupil associated with a 10% increase in the outside wage. The cross-sectional relationship is largest in 2005 at one GCSE point lost per student, which is equivalent to one GCSE grade. This significant negative coefficient is small (the mean KS4 points is 44) but provides preliminary evidence that the teacher pay structure in England adversely affects school performance.

4 Methodology

A simple education production function in the spirit of Loeb and Page (2000), which considers the importance of controlling for alternative labour market opportunities when examining the degree to which teacher wages affect student outcomes, is:

$$KS4_{i,t} = \alpha + \beta(lnW^{I}_{i,t-1} - lnW^{O}_{i,t-1}) + \rho KS2_{i,t-5} + \gamma' X_{i,t} + \mu_t + f_i + \epsilon_{i,t} \quad (1)$$

where $KS4_{i,t}$ is the average Key Stage 4 point score for school i at time t, and $KS2_{i,t-6}$ is the average point score from Key Stage 2 exams of all individuals who took Key Stage 4 examinations in school i. By measuring KS4 scores as the outcome variable and controlling for KS2 scores we are measuring value added by the school to the pupil from entry to the end of compulsory schooling. W^{I}_{t-1} is the inside, teacher wage, W^{O}_{t-1} is the outside wage, X is a vector of controls at cohort (the

[20] We tested that our results are robust to exclusion of small pupils cohorts (less than 30 students) to address potential problems in the reliable measurement of school outcomes when cohorts are small (Kane and Staiger (2002).

[21] Results using value added as the dependent variable and excluding the KS2 score are extremely similar.

year group), school and Local Authority levels (as presented in the data section above), μ_t is a set of time dummies and f_i is a time invariant school fixed effect.

We do not observe inside (school) wages. But these are fixed over schools in the same (large) region by the pay regulation and any variation which we could observe at school level is likely to be endogenous (for example, if schools in high outside areas wages over-promote teachers to retain them). We therefore focus on estimating only the effect of the outside wage, which measures the gap between actual teacher wages and the potential outside labour market wage a teacher could command and is exogenous to teacher wages (see also Propper and van Reenen (2010)).

However, a model with only a one period lag in wages is problemmatic. Pupils in England attend the same secondary school for five years. This has two consequences. First, since education is cumulative and final examination results will depend on the education a pupil received in all of the years they attended the school, it is likely that long lags will exist on the outside wage. [22] Thus a regression with only one lag in wages is likely to suffer from omitted variable bias. While in principle we could estimate equation (1) with 5 lags of wages, in practice the outside wages in year t are likely to be not dissimilar to those in year t-1. Identification of the separate effect of each years wages is therefore likely to be difficult. Second, since teachers teach children across year groups, different year groups will be subjected to the same shocks. This is likely to create high levels of serial correlation in the outcome data.

In the Appendix we examine the impact of these two problems. We first detail the issue, then undertake some preliminary estimation to check what we are able to estimate with multiple lags in wages. We present both OLS and fixed effects estimates which include five lags in wages (from t-1 to t-5) and examine both the individual coefficients and the average estimated effect. We also present tests for serial correlation. These results are discussed at more length in the Appendix but, in short, we find negative effects of wages for several of the lags, an overall average negative effect, and high serial correlation. These estimates show the problem of estimating a full dynamic model, but they also confirm that there appears to be a negative relationship between outside wages and value added.

Our solution to these problems is to utilize the fact that pupils are in secondary schools for five years between entry post-KS2 and taking their KS4 exams. To get round the problem that a shock in year t will affect all children in the school, we use the data so that there are five-year gaps between each school level observation. Thus there are no overlapping cohorts of pupils across the school level observations. To address the long lag structure, we impose the assumption of common effects in the lagged wages and estimate the effect of an average outside wage, defined over a five-year period (i.e. from $t-1$ to time $t-5$). This has the additional advantage of averaging away some of the noise in the annual wages. The model we estimate is:

[22] Further justification of a long lagged effect on outside wages is the effect wages may have on the supply of quality teachers; for example individuals may be deterred from entering teacher training as a consequence of the poor relative wage. If this were the case, it would clearly be some time before pupil results were affected.

$$KS4_{i,t} = \alpha + \beta\left(\frac{1}{5}\sum_{k=1}^{5} W^{O}_{i,t-k}\right) + \rho KS2_{i,t-5} + \gamma' X_{i,t} + \mu_t + f_i + \epsilon_{i,t} \quad (2)$$

The explanatory variable of interest is the school outside wage averaged over five years from $t-1$ to $t-5$, and the dependent variable is school level mean KS4 points obtained at time t. We present results using OLS and fixed effects estimators, using the fixed effects approach to alleviate bias caused by unobserved heterogeneity. A disadvantage of this approach is that, as we have data for 2002-2008, this gives us only two observations per school. However, we do have a large sample of schools, a rich set of controls and the two observations per school allow us to control for time invariant heterogeneity at school level.

5 Results

The results are in Table 2. Columns [1] and [2] present the OLS estimates and [3] and [4] the fixed effects estimates. The coefficients on the outside wage are negative and significant in all estimates. The coefficients represent the estimated change in average GCSE points per pupil associated with a 10% increase in the five-year average wage. The loss of one GCSE point is equivalent to dropping one GCSE grade in one subject. For both the fixed effects and OLS estimates, the estimated effect increases in magnitude with the inclusion of the controls. The Fixed Effects estimates are larger than the OLS estimates.[23] Column [4] - our preferred specification - estimates a loss of approximately 1 GCSE point per pupil in response to a 10% increase in the average wage.

5.1 Robustness Tests

We now subject these results to checks to examine whther particular schools or labout markets drive our results as well as robustness to the definition of key variables. In Section 6 we investigate other possible explanations for our results, including the potential endogeneity of the outside wage and the possibility that the outside wage affects school performance through some mechanism other than the behavior of teachers. Table 3 present our battery of tests. All results are from Fixed Effects regressions with time dummies and the full set of controls. Regression [1] presents the baseline specification from column [4] of Table 2.

5.1.1 Differences across labour markets

It is possible that our results are driven only by schools in London where outside wages are highest. To examine this column [2] excludes London schools, whilst column [3] narrows it down further and examines only schools that are within one single pay band within which there is no regional

[23] This suggests an unobservable factor that is positively correlated with both outside wages and school performance. An example might be a board of governers (the quality of the board of governers could be greater in high outside wages, improving school performance), or the quality of headteachers. As headteachers operate in unregulated labour market a good headteacher might choose to teach in schools in higher outside wage areas.

variation in teacher pay. This is the lowest pay-band (known as the 'Rest of England') and covers a large area - all of England excluding London and the area around London.[24] The results in columns [2] and [3] are changed little by these exclusions, so the effects are not driven by London schools.

If our hypothesis is correct, schools facing more competition from other schools should have more problems in recruiting and retaining staff when subject to outside wage shocks. In column [4] schools which face low levels of competition from other schools are excluded from the analysis.[25] The wage coefficient increases by around 40%. We find a similar result when excluding rural schools or schools in Local Authorities with low population densities from the sample. These results suggest that competition amplifies the effect of a wage shock.

5.1.2 Differences by school control over wages

In England, secondary schools are classified into a number of types, the most common being Community Schools. These schools are not permitted to select pupils and Local Authorities have complete autonomy over their curriculum and teacher wages. In the other types of state schools pupil selection is sometimes an option (for example, publicly run religious schools) and there is, in theory at least, more flexibility in terms of teacher wage setting.[26] To test whether the effect is larger where schools have no control over their wages in column [6] we include only Community Schools. The results show that the magnitude of the coefficient increases. We also find that wage effect for non-community schools is lower and not statistically significant.[27] These results support our argument: we observe a stronger effect amongst schools with no power at all over their wage setting. [28]

5.1.3 Changes in the definition of value added

In columns [6], [7] and [8] we explore the robustness of our results to changes in the definition of value added. First, we use the 'capped KS4' scores (the average score taken from a students best eight GCSE grades) rather than raw total scores, then we drop KS4 outliers and finally we use the official Value Added measure (excluding KS2 scores as a control). Column [6] shows the coefficient on the outside wage is smaller when capped value added is used as the dependent variable. This perhaps suggests that the ability to allow children to take lots of exams is a sign of school quality in itself and outside wages affect this margin more than basic performance. The results are robust to our other experiments with the value added definition.

[24] As discussed in the Institutional Background teacher pay is allowed to vary across four pay bands; Inner London, Outer London, 'The Fringe' and the 'Rest of England'.

[25] A school with low local competition is defined as a school with eight or fewer schools within a 10km radius. This results in the exclusion of approximately 28% of schools.

[26] The most prominent example of a school type with the power to set teacher wages is the new Academy Schools, although there were very few Academies in our sample period.

[27] Wage coefficient = -0.265, s.e.= 0.561.

[28] The smaller impact in the other types of state schools may either indicate that some wage setting does exist and/or that the better conditions in these schools make teachers less responsive to wages.

5.1.4 The definition of the outside wage

In our main specification we use the (five year) average of the non-manual male outside wage lagged by one year for a 30Km TTWA. Our results do not hang on the precise definition of wages. They are robust to using either the mean of the log of weekly rather than hourly wages or specifying the wages in levels.[29] They are robust to the definition of the radius of the TTWA. We alter this definition in 10km steps from 10km to 120km and estimate a wage effect for each radius in this range. We show the coefficients and the associated 95% confidence intervals in Figure A1. This figure clearly shows the results are insensitive to different choices of the radius for distances between 20 and 80km. Larger areas cannot really be considered to be a TTWA. We also find no effect at a radius of 10km. It is possible at this small radius wages are endogenous; we return to this in Section 6.1.[30] We also investigated whether there is less response to a less relevant measure of outside wage. In column [9] we define the outside wage to be that of manual workers. Teachers are graduates and should therefore be less likely to respond to shocks to the wages of less skilled workers. The smaller coefficient supports our main results.[31]

5.1.5 Annual Data

In our main specification we are restricted to two observations per school. To relax this we present estimates of current outcomes as a function of wages lagged one year. We then repeat this for wages lagged twice and so on, upto six years. This allows us to use more observations per school than in our main regressions. The results in Table 4 show that we can identify a wage effect when we use more observations per school. It is also clear that the wage effect operates with a lag, but given the structure of schooling this is not surprising. [32]

On the basis of this battery of tests, school performance appears to be responsive to shocks to wages in the local labour market and this relationship is robust to a wide range of specification changes. However, it is possible that the wage effect operates through some mechanism other than through teacher responses and we now turn to address this potential concern.

[29]Results available from the authors. The choice of the 60km cutoff for schools with no Local Authority whose headquarters lie within a 30km radius does not to affect the results. Neither setting this cutoff at 30km (so that schools without the HQ of a Local Authority within 30km are excluded), nor not having a cut-off (so that schools are simply matched to the Local Authority whose HQ is nearest if none lie within 30km) affects the results.

[30]This smaller coefficient is not due to the reduced sample size as the coefficient with the same set of schools as in the 10km regression but with a TTW radius of 30km is -1.432*** (s.e.=0.573). We also weighted wages by the inverse of the distance from the school to the LAs. This had little impact on the results.

[31]We also examined using non-manual female wages as the outside wage. The wage effect is smaller and not significantly different from zero using logged wages but the result is sensitive to functional form: female wages have a similar effect to male wages if wages are specified in levels rather than logs. This suggests that there may be a problem of lack of precision in our estimates of female outside wages due to smaller sample of observations of female wages at LA level. Note that only slightly more than half of secondary school teachers are female.

[32]The results in Table A3, in which we present estimates from a richer dynamic model, also provide support for a negative relationship between wages and value added.

6 Mechanisms

We explore two alternative explanations for our findings: first, whether the relationship we find is driven by reverse causality and second, whether our results are driven by the responses to outside wages of pupils and/or parents rather than of teachers. We also investigate one potential causal path though which the wage effect may operate, examining whether wage shocks operate through teacher vacancies.

6.1 Endogeneity of Wages

School performance could affect outside wages, which would bias our results. The most obvious mechanism by which school performance may affect outside wages is through sorting: good schools attract high income parents to move into the area surrounding a school.[33] This would give a positive shock to the average outside wage and would bias our estimated coefficients upwards. While we use lagged outside wages because of the high levels of serial correlation in both the outside wage and in KS4 results, this endogeneity problem could remain.[34] However, the 30 km radius TTWA we use makes this argument less valid. Using the catchment area of a school to determine the outside wage would indeed be problematic, as people try to buy houses in the catchment areas of 'good' schools in order to send their children there. But much of that gaming is within area. Individuals are likely to choose areas based on their job and general lifestyle choice and then select their specific within-area locations based on the schools available. We have shown that we find a significant relation between outside wages and school performance at 30km and at larger radii which are areas which are large enough to capture this within area gaming. We additionally find that the effect is smaller at 10km and at 20km (see Figure A1). TTWA radii of these distances give more weight to the local catchment area round each school, which may indicate endogeneity at this spatial distance.

6.2 A Pupil or Parental Effect?

Outside wages may affect school performance through the responses of pupils or parents rather than those of teachers. For example, the observed relationship between outside wages could be driven by pupil responses to outside wages as they change their behavior in examinations in response to shocks to the local labour market. To examine this, we look at the effect of the local youth labour market on school performance. If the effect is primarily driven by pupils responding to better labour market opportunities by decreasing their effort at school because they know there is an employment alternative to staying on at school, we would expect to find both a negative relationship between school performance and either higher outside wages or the demand for youth labour. As a direct

[33] If people live in a school's catchment area, they automatically qualify for a place in that school if they choose to take it. In the UK, houses in the catchment areas of particularly good schools are more expensive due to high demand for housing in the area.

[34] An Arellano-Bond type estimator is not appropriate in our case because of the high degree of serial correlation in the dependent variable over several years.

test of a pupil effect, we replace the outside wage in our model with the Local Authority level employment rates of 16-24 year olds.[35] We find no significant effect of youth employment rates on school performance.[36] Further, for the observed negative relationship between outside wages and school performance to be driven by a pupil response, pupils would have to be responding negatively to positive wage shocks, or equivalently positively to negative wage shocks. Whilst this is plausible, pupils might be as likely to respond to positive wage shocks by putting in more effort at school, on the grounds that if they get better exam grades they are more likely to get a job. This would mean the coefficient we observe is a lower bound of the effect on teachers.

An outside wage shock would also be a positive shock to parental income. This could lead to better exam performance if higher parental income causes their children to have better exam performance. However, the literature suggests that this effect is likely to be small. While parental income has been shown to have a causal impact on child attainment (for example, Blanden and Gregg (2004)), shocks to income are more important in the early, rather than the later years of childhood (Tominey (2009)). Further, the lack of significance of full time male manual wages brings into doubt whether the effect is working through parental income, as whilst it is easy to argue that the coefficient is insignificant because teachers are less influenced by non-manual wages, it less easy to argue that a parental income effect exists only for parents in non-manual occupations. Finally, as the literature shows a positive effect of parental income on child attainment, it seems very unlikely that the negative relationship between outside wages and child attainment is being driven by a parental effect, as this would require positive shocks to parental income to negatively affect child attainment.

In summary, our tests suggests our results are not driven by a pupil or parental, rather than a teacher, response to outside wages. In fact, whilst pupils and parents might respond, they probably do so in a way which biases our estimated coefficients towards zero.

6.3 Vacancy Rates

If shocks to outside wages are affecting school performance through teachers, it is likely they are working through two channels: through teacher supply and through teacher effort. If much of the effect is working through teacher supply, we would expect to observe a positive relationship between outside wages and teacher vacancies. Elliott et al (2009) examine this for the UK and find a positive relationship, which they attribute to the lack of flexibility in teacher wages. To investigate whether outside wages affect performance through vacancies, we re-estimate our main specification including the local area (LEA) teacher vacancy rates as an additional control. We find that the inclusion of vacancy rates reduces the coefficient on the outside wage by approximately 30% to -0.739* (this is significant at the 10% level, with a standard error of 0.387). The coefficient on vacancies is negative and significant at the 1% level: the coefficient is -0.056 with a standard

[35] We match Local Authority level NOMIS data into our PLASC dataset and include the lagged employment rate in our regressions.

[36] The fixed effects regression estimate of a ten percent change in the Local Authority level employment rate is very small and has a coefficient of -0.024, standard error of 0.063.

error of 0.017.[37] This suggests that around one third of the relationship between outside wages and school performance could be explained by the effect of outside wages on teacher vacancies.[38] We would attribute the remainder of the effect of shocks to local labour market wages to their effect on teacher effort and on the average quality of teachers, but we are not able to examine this further as we do not observe teacher effort or quality. [39]

7 Investigating Regional Heterogeneity

We now investigate non-linearity in the effect of wage shocks and school performance. This is important for welfare calculations since a linear relationship suggests that losses to pupils in high wage areas are offset by gains to those in low wage areas. On the other hand, if there convexity in the wage effect, a policy change which increased wages in high wage areas whilst decreasing them in low wage areas could be welfare increasing.

We investigate this in Table 5. We categorize schools as being in one of three 'outside wage regions' and investigate differences across these three regions. In columns [1] - [3] schools are classified into outside wage regions on the basis of the average wage for the sample period at the broad Government Office Region (GOR) level (there are ten GORs in England).[40] In column [4] the split is based on the average non manual wage at Local Authority level for the sample period. In column [5] the split is based on our TTWA definition of the schools outside wage over the sample period. All the results show a heterogeneous response by schools across regions, with greater response in schools located in the higher outside wage regions. In column [1], for example, the interaction term for the high wage region is around half the size of the main effect. These conclusions are insensitive to exactly how we define the how we define outside wage region, as shown in comparison of columns [1], [4] and [5]. These results echo Propper and Van Reenen (2010) who found convexity in the relationship between outside wages and hospital performance, such that the relationship between outside wages and hospital performance was stronger in high outside wage regions. This finding has welfare implications, as it suggests that removal of regulation to increase teacher wages in high outside wage areas while reducing them in low outside wage areas could result in a net improvement in school performance across the country.

7.1 A Cost-Benefit Analysis

Our analysis suggests regulation that imposes a common wage across heterogeneous wage regions has costs. We therefore conduct a thought experiment in which we remove the regulation and

[37] A one standard deviation change in the vacancy rate is associated with the loss of around half a GCSE point per pupil.

[38] These results should be treated with caution. While we use the same data as Elliott et al (2009), vacancy rates are often very low.

[39] The two are highly linked and difficult to separate e.g., Ronfeldt et al (2011) who show that low quality teachers affect the performance of their high quality peers.

[40] We split the GORs into approximate terciles on the basis of ASHE average non-manual full time weekly wages (see Table A4).

allow teacher wages to be more reflective of broad local labour markets (the high, medium and low outside wage regions defined according to GORs). Table 6 provides a set of estimates of this.

In column [1] we present estimates of the change in the teacher wage bill following removal of regulation. This is equal to the change in wages multiplied by the number of teachers in each of the three regions.[41] We derive the counterfactual wage from Labour Force Survey (LFS) data, adjusting non-manual wages to estimate wages that would be paid to individuals with the human capital level of teachers (see Appendix for details). Since teacher wages are simply a transfer, the social cost (saving) associated with a rise (fall) in the overall teacher wage bill is only the excess (saved) deadweight loss from taxation. This is given in column [2], where the deadweight loss is set equal to 30% in all experiments unless stated otherwise.

Column [3] estimates the gain from the removal of regulation. We present a conservative estimate of this. An increase in value added will affect all pupils but we value only the change for those pupils at a critical point in the KS4 distribution. This is the attainment of five A*-C GCSE grades.[42]Approximately 20% of pupils attain between three and five GCSEs (Britton et al (2011)). In this region the distribution of GCSE points is approximately linear so we assume that 5% of pupils are within half a GCSE point of the cutoff and 10% are within one GCSE point of the cutoff. Given this, we estimate the average increase number of pupils getting five A*-C grades as follows. We multiply the region-specific percentage change in the teacher wage following the removal of regulation by one tenth of the absolute value of the (region-specific) wage estimate from column [3] of table 5.[43] Given our assumption of linearity this percentage change is the percentage change in the number of pupils who cross the threshold. We multiply this by the total number of pupils in the region to derive the additional number of pupils that cross the threshold as a result of the policy change.

In column [4] we present estimates of the value of this gain. Sianesi (2003) estimates the earning premium from attaining five A*-C GCSE grades (compared to attaining four) to be 12%. We increase the regional average wage of individuals with fewer than 5 GCSEs by 12%. We then multiply this by the extra number of pupils gaining these qualifications. This figure is then multiplied by 20, as a conservative estimate of the increase in lifetime earnings, and discounted using a discount rate of 0.95.

The ratio of gains to losses of the policy is presented in two ways. In column [5] we present the ratio of the increase in teacher wages to the number of pupils who now attain five A*-C GCSEs. But this calculation ignores the fact that the increase in teacher pay is a transfer and does not value of the gain to the pupils. In column [6] we present the overall net social benefit, which is the sum of the increase in lifetime earnings minus the deadweight loss associated with the increase in the teacher wage bill.

[41]In 2010/ 11 there were 59600 state secondary school teachers in the high wage region, 74600 in the middle wage region and 75200 in the low wage region. Source: Dept for Education.

[42]Five A*-C GCSE grades are commonly required to continue in education beyond the minimum school leaving age.

[43]We assume the effect of increasing the teacher wage is the same as decreasing the outside wage. The wage coefficient in table 5 is the estimated change in GCSE points associated with a 10% increase in the outside wage.

Our baseline estimate is given in row [1] of Table 6. In this row we use counterfactual wage estimates from the LFS which indicate that removal of regulation would increase teacher wages by £3060 in the high wage region and would decrease them by £464 and £1739 in the medium and low wage regions. We set the wage coefficients to be -1.056, -0.94 and zero in the high, medium and low wage regions respectively, based on the estimates in Table 5, and the deadweight loss from taxation to be 30%.

The increase in the wage bill would be £17 million and the deadweight loss of this is just over 5m. The number of pupils gaining is just over 11,000.[44] The financial cost per pupil is £1511. This is dwarfed by the net social gain of £419 million, as the cost of paying teachers more very small compared to the lifetime gain in earnings for their pupils.

In row [2] the DW loss from taxation is increased to 60% keeping all other parameters as in row [1]. Although this increases the cost to society to around £10 million, the overall social benefit is little changed. In row [3], we lower the assumed wage premium from 12% to 6%. This halves the discounted value of the policy and so has a large effect on the overall social gain. But it still remains large and positive at £207 million. In row [4] we lower the estimated effect of a teacher wage increase by reducing the estimated wage effects by one standard error. They fall to -0.699 and -0.581 in the high and medium wage regions respectively (the coefficient in the lowest outside wage region is kept at zero). These values are very similar to the OLS estimates in Table 2. The table shows that, even in this case, an estimated extra 7534 pupils attain 5 A*-C GCSEs. The overall change in the teacher wage bill is the same as in the baseline case and so the policy has a financial cost of just under £2300 per pupil. But the overall net social returns remain very large at £279 million. This shows that even if we are very cautious with our choice of coefficient (as the results in Table 2 suggest we should be), there remains a large social gain to the change in policy.

In rows [5] and [6] we increase the counterfactual teacher wage in each of the three regions. The LFS estimates suggest a counterfactual wage in the medium wage region which is below the estimated average teacher wage in that area. But this is inconsistent with our finding of a negative wage estimate for this region in Table 5. This suggests our counterfactual LFS wage estimate is too low. We therefore increase the counterfactual wage by £464 in each region in row [6] to make the difference between the counterfactual wage and the teacher wage in the medium wage region zero. In row [6] we increase it further by £1464 in each region to make the difference between the counterfactual wage and the teacher wage in the medium wage positive (£1000). In both cases the number of additional pupils attaining five A*-C GCSEs increases, to over 16000 in row [5] and to over 26000 in row [6]. However, these increases are expensive; in row [6] the teacher wage bill increases to £114 million (with an associated deadweight cost to society of £34 million) and the

[44] This is estimated as follows. For the high wage region the 8.4% increase in the teacher wage would result in an increase of 0.89 GCSE points per pupil (1.056*0.84). Given the assumed distribution around the five A*-C GCSE grade cutoff, this means that an additional 8.9% of pupils in the region will move above the cutoff. In the medium wage area, the wage coefficient is estimated to be -0.94. The wage decrease of £464 is therefore a 1.4% decrease, which is therefore associated with some people moving below the cutoff. The wage estimate in the low wage region is set to zero, so the reduction of the teacher wage in this region does not result in any pupils moving from above to below the cutoff.

cost per additional pupil attaining five A*-C GCSEs rises to over £7000. In row [6] the wage bill increases to £323 million (with an associated deadweight cost to society of £97 million), and the financial cost per additional pupil rises to £12000. However, in both cases, the overall social gain rises because of the responsiveness of pupil attainment to wages and is £571 million in row [5] and £900 million in row [6].

In summary, these calculations show that while the financial cost per pupil rises quite rapidly with an increase in the counterfactual wage, the fact that the gain has a large lifetime payoff means that the net social gain remains very large. This holds even when being very cautious about who gains from the inprovment in school performance, and by how much they gain (regarding both the magnitude of the coefficient, and the wage premium period). While such changes might meet union resistance (which itself has a cost), we show that the total social gains could be very large.

8 Conclusion

Unionization on the supply side, and public ownership on the demand side, of the teacher labour market means that teacher wages are frequently set to be flat across heterogenous local labour markets. This paper exploits the flat pay structure of teacher wages and the use of national exams at entry into and exit from secondary (middle/high) schooling in England to examine the effect of such wage setting practices on pupil value added. We find that pay regulation reduces school performance. We also find the response is non-convex across heterogeneous labour markets so that the losses from keeping wages too low in high cost areas outweighs the gains from over-paying in low cost areas.

The average effect is relatively small. A 10% increase in the local labour market wage would result in an average increase of 2% in the scores attained in the high stakes exams taken by pupils at the end of compulsory schooling in England. But the number of pupils who would benefit from any gain in teacher performance, the fact that the associated gain in education will have returns over a long time period and the non-convexity in the response to wage regulation, means that the long term gains from the removal of regulation could be very large.[45]

Our finding that teachers perform better in response to positive shocks to their wages, and worse in response to negative shocks to their wages, fits more broadly with the literature suggesting that teacher pay is important for performance. Whilst much recent policy on teacher wages has focused on pay for performance (e.g. Lavy 2009), centralised pay setting affects teachers in many more countries than are using pay for performance in the classroom. This suggests that policy effort should be directed towards increasing flexibility in centralized wage bargaining.

[45] In the English context, government policy to promote flexible wages for teachers would give more public resources to richer areas of the country, any increase in public sector teacher wages in these areas is not necessarily a policy focused on the rich, since pockets of high deprivation exist within many of these areas. Further, richer parents in these areas are far more able than poorer ones to substitute away to better state schools further afield or into the private sector (Taylor 2002) and thus avoid the negative consequences of centralized wage rates. There would also be a potential positive long run effect of improving public sector schools in high outside wage areas if the more wealthy were encouraged back into the public sector, which could positively impact the rest of the school through positive peer effects (Feinstein and Symonds 1999).

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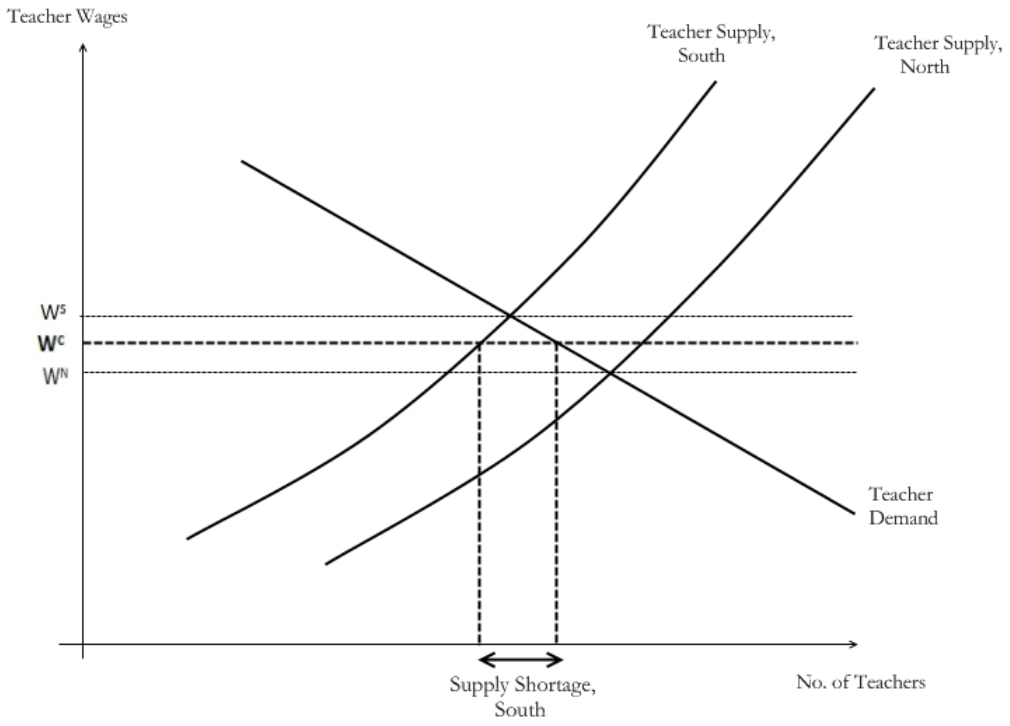
Figures

Figure 1: Dual-Region Model of Teacher Pay



Tables

Table 1: Cross Sectional Estimates

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Year	2002	2003	2004	2005	2006	2007	2008
$Outwage_{t-1}$	-0.548***	-0.463**	-0.705***	-0.800**	-0.528***	-0.209	-0.448
	(0.126)	(0.182)	(0.199)	(0.233)	(0.256)	(0.264)	(0.308)
N	2964	2984	2996	3015	3018	3035	2986

Results from OLS regressions. Dependent variable is school-level KS4 point score, key explanatory variable is the log of the corrected outside wage (lagged once). Standard errors clustered at LA level. Within-school cohort level controls for nine different ethnicities, proportions of Free-School Meal, Male, English-first-language and Special Educational Needs (both severe and non-severe) students are used. School level controls for expenditure per pupil, proportions of Free School Meal, Male, and Special Educational Needs students, and Local Authority level controls for proportions of private and selective school attendees and the area population density are used. LA dummies also included. * = significant at the 10% level, ** = significant at the 5% level and *** = significant at the 1% level.

Table 2: Estimated Outside Wage Effect Using Five Year Gaps Between Observations

	OLS		FE	
	[1]	[2]	[3]	[4]
$OutsideWage$	-0.490***	-0.608***	-1.006***	-1.070***
	(0.158)	(0.153)	(0.342)	(0.343)
Controls	No	Yes	No	Yes
No. Schools	2949	2949	2949	2949
N	5898	5898	5898	5898

Dependent Variable is mean KS4 point score aggregated at school level. Key explanatory variable is log of the corrected outside wage averaged over the period t-1 to t-5. Standard errors are clustered at school level. Within-school cohort level controls for nine different ethnicities, proportions of Free-School Meal, Male, English-first-language and Special Educational Needs (both severe and non-severe) students are used. School level controls for expenditure per pupil, proportions of Free School Meal, Male, and Special Educational Needs students, and Local Authority level controls for proportions of private and selective school attendees and the area population density are used. * = significant at the 10% level, ** = significant at the 5% level and *** = significant at the 1% level.

Table 3: Robustness Checks

	Main Specification	Excluding London	Within Payband Four Only	Excluding Schools with Low Local Competition	Community Schools Only
	[1]	[2]	[3]	[4]	[5]
Average Wage	-1.070***	-1.084***	-0.994**	-1.366***	-1.357***
	(0.347)	(0.353)	(0.389)	(0.494)	(0.350)
No. Schools	2949	2585	1999	2144	1825
N	5898	5170	3998	4288	3650

	Capped KS4 Scores as the Dependent Variable	Without KS4 Outliers	Value Added as the Dependent Variable	Manual Wages
	[6]	[7]	[8]	[9]
Average Wage	-0.488***	-1.550***	-1.075***	-0.564
	(0.170)	(0.343)	(0.355)	(0.437)
No. Schools	2949	2534	2949	2949
N	5898	5068	5898	5898

All results from fixed effects regressions, with same specification and set of controls as in regression [4] of table 3, unless stated. * = significant at the 10% level, ** = significant at the 5% level and *** = significant at the 1% level.

Table 4: Estimation with Lagged Wages

	Lag on the Outside Wage					
	1	2	3	4	5	6
OLS	-0.225*	-0.443***	-0.368***	-0.458***	-0.532***	-0.560***
	(0.117)	(0.115)	(0.114)	(0.120)	(0.117)	(0.128)
Fixed Effects	0.383***	-0.099	0.074	-0.241**	-0.464***	-0.555***
	(0.100)	(0.106)	(0.104)	(0.117)	(0.108)	(0.116)
No. Schools	3048	3048	3048	3048	3048	3048
N	20991	20991	20991	20991	20991	18026

* = significant at the 10% level, ** = significant at the 5% level and *** = significant at the 1% level.

Table 5: Heterogeneity across outside wage regions

	Outside Wage Region Definition				
		Regional		LA	School TTWA
	[1]	[2]	[3]	[4]	[5]
Outside Wage	-0.872**	-0.989***		-0.853**	-0.874**
	(0.350)	(0.345)		(0.355)	(0.359)
HW Region * Outside Wage	-0.421***		-1.056***	-0.351***	-0.285**
	(0.128)		(0.357)	(0.132)	(0.133)
MW Region * Outside Wage			-0.940***		
			(0.349)		
LW Region * Outside Wage		0.632***	-0.356		
		(0.116)	(0.368)		
No. Schools	2949	2949	2949	2949	2949
N	5898	5898	5898	5898	5898

Dependent Variable is mean KS4 point score aggregated at school level. The key explanatory variable is log of the corrected outside wage averaged over the period t-1 to t-5. The High, Medium and Low Wage Variables are interactions between the outside wage and a dummy variable set equal to one if a school is in a given region. In regression [3] the coefficient is allowed to vary across the three regions. In regressions [4] and [5] the definition of High Wage regions is altered, with little impact on the results. Controls are included, as in Table 3. * = significant at the 10% level, ** = significant at the 5% level and *** = significant at the 1% level. Standard errors are clustered at school level.

Table 6: Cost Benefit Analysis

	Costs of Policy		Benefits of Policy			
	Increased annual teacher wage bill (£m)	Increased DW loss from taxation (£m)	Increased no. pupils attaining 5 A*-C GCSEs	Discounted total increase in lifetime earnings (£m)	Financial Cost per pupil (£) ([1]/[3])	Net social benefit (£m) ([4] - [2])
	[1]	[2]	[3]	[4]	[5]	[6]
1. Baseline Case	17.0	5.1	11,247	696	1,511	419
2. 60% DW Loss	17.0	10.2	11,247	696	1,511	414
3. 6% increase in earnings	17.0	5.1	11,247	348	1,511	207
4. Wage estimate -1se	17.0	5.1	7,534	466	2,255	279
5. Higher CF Wage	114.2	34.2	16,043	993	7,115	571
6. Higher CF Wage	323.6	97.1	26,378	1,633	12,266	898

All figures are per year (or per cohort). The estimated DW loss is 30% unless stated otherwise. The estimated average wage just below the 5 A*-C cutoff is £25800. The change in teacher wage is equal to the counterfactual wage minus the average teacher wage for each given region. The average teacher wages are estimated at £36409, £33240 and £33263 for the high, medium and low wage regions respectively. All data come from the LFS with the exception of the number of pupils in each region (PLASC) and the number of teachers in each region (Department for Education).

A Appendix

A.1 Data Sources

The data sources used in this paper are given in Table A1.

Table A1: Data Sources

	Source of Data	Years
School Value Added (KS4 and KS2 grades) and Case-Mix Controls	Pupil Level Annual School Census (PLASC)	2002-2008
Outside Wage Data	Annual Survey of Hours and Earnings (ASHE)	1997-2007
Counterfactual/Average Teacher Wages, LA Level Employment Rates	Labour Force Survey (LFS)	2001-2008
Teacher Vacancy Data, Number of Teacher by GOR	Department for Education	2003-2008

A.2 Descriptive Statistics

Table A2: School Level Summary Statistics

Variable		Mean	Standard Deviation	Minimum	Maximum	Observations
Key Stage 4	Overall	43.84	10.46	0	99.01	6222
	Between		9.684	0	91.71	
	Within		4.471	20.30	67.37	
Key Stage 2	Overall	26.64	1.959	19	33.42	6221
	Between		1.770	19	32.73	
	Within		0.899	24.19	29.09	
Outside Wage	Overall	7.362	0.147	6.991	7.776	6301
	Between		0.124	7.123	7.725	
	Within		0.079	7.169	7.555	
Average Wage (5 Years)	Overall	7.271	0.161	6.844	7.746	6301
	Between		0.12 4	7.000	7.638	
	Within		0.102	7.115	7.428	
Private (LA Level)	Overall	0.100	0.076	0	0.657	6222
	Between		0.076	0	0.654	
	Within		0.005	0.069	0.130	
Selective (LA Level)	Overall	0.094	0.216	0	0.964	6222
	Between		0.214	0	0.964	
	Within		0.005	0.045	0.144	
Pop Density (LA Level)	Overall	1692.96	2184.18	62	13609	6222
	Between		2212.73	62	13609	
	Within		0	1692.96	1692.96	
Expenditure Per Pupil	Overall	4.122	1.125	1.375	26.74	6123
	Between		0.852	2.222	26.74	
	Within		0.831	-4.421	12.67	
Free School Meals	Overall	0.137	0.130	0	1	6221
	Between		0.129	0	0.875	
	Within		0.029	-0.241	0.515	
Male	Overall	0.506	0.189	0	1	6222

	Between		0.186	0	1	
	Within		0.030	0.241	0.771	
White	Overall	0.831	0.241	0	1	6222
	Between		0.232	0	1	
	Within		0.073	0.331	1.331	
Black Caribbean	Overall	0.016	0.045	0	0.75	6222
	Between		0.045	0	0.718	
	Within		0.010	-0.082	0.114	
Black African	Overall	0.016	0.048	0	1	6222
	Between		0.047	0	0.517	
	Within		0.015	-0.467	0.498	
Black Other	Overall	0.007	0.024	0	1	6222
	Between		0.025	0	1	
	Within		0.010	-0.127	0.140	
Indian	Overall	0.024	0.069	0	1	6222
	Between		0.068	0	1	
	Within		0.013	-0.142	0.189	
Bangladeshi	Overall	0.010	0.052	0	0.995	6222
	Between		0.051	0	0.965	
	Within		0.007	-0.159	0.178	
Pakistani	Overall	0.026	0.087	0	0.957	6222
	Between		0.087	0	0.923	
	Within		0.012	-0.124	0.173	
Chinese	Overall	0.004	0.007	0	0.112	6222
	Between		0.006	0	0.076	
	Within		0.004	-0.038	0.045	
Other	Overall	0.043	0.072	0	1	6222
	Between		0.064	0	1	
	Within		0.040	-0.445	0.531	
English First Language	Overall	0.908	0.181	0	1	6221
	Between		0.177	0	1	
	Within		0.043	0.408	1.408	
SEN (severe)	Overall	0.024	0.021	0	0.394	6222
	Between		0.019	0	0.307	
	Within		0.010	-0.080	0.127	
SEN (non severe)	Overall	0.155	0.111	0	1	6222
	Between		0.098	0	0.728	
	Within		0.056	-0.240	0.550	
School FSM	Overall	0.151	0.264	0	1	6222
	Between		0.219	0	1	
	Within		0.157	-0.349	0.651	
School White	Overall	0.821	0.237	0	1	6222
	Between		0.231	0	1	
	Within		0.064	0.332	1.309	
School Male	Overall	0.507	0.182	0	1	6222
	Between		0.181	0	1	
	Within		0.014	0.356	0.658	
School SEN (sev)	Overall	0.024	0.017	0	0.25	6222
	Between		0.016	0	0.237	
	Within		0.007	-0.050	0.098	
School SEN (non sev)	Overall	0.111	0.095	0	0.700	6222
	Between		0.072	0	0.559	
	Within		0.066	-0.192	0.414	

All wage data come from ASHE from 1997 to 2007, while all other data come from PLASC and run from 2002 to 2008. All variables are aggregated at cohort level (where a cohort includes all individuals in a given school in the same school year) for each of the 3285 schools unless indicated - as seen some are at school level, while others are at local authority level. The population density variable is time invariant due to a lack of data.

A.3 Estimation Issues

We present a simple representative model highlighting why there is likely to be a distributed lagged effect of the outside wage on final attainment and why high levels of serial correlation are likely to be present in a schools annual exam results. To begin, we allow the cohort level average KS4 results within each school in year t to depend on a weighted sum of five years of unobserved value added to the cohort in each year they are in the school:[46]

$$KS4_t = \Pi_1 VA_{1,t-4} + \Pi_2 VA_{2,t-3} + \Pi_3 VA_{3,t-2} + \Pi_4 VA_{4,t-1} + \Pi_5 VA_{5,t} \tag{3}$$

Where $VA_{m,n}$ is the average value added to the cohort taking exams at time t in school year m, at time n.[47] The Π's are numerical weights. We model value added in school year m to be equal to a school effect common to all pupils in the school plus an idiosyncratic cohort shock:

$$VA_{m,n} = VAS_n + \epsilon_{m,n} \tag{4}$$

Shocks to outside wages will affect the whole school rather than just the final year cohort. We allow these school level shocks to be dependent on lagged outside wages and a school level time-invariant fixed effect, so that:

$$VAS_n = \sum_{k=1}^{p} \lambda_k W_{n-k} + S \tag{5}$$

Where W is the outside wage and S is the school level fixed effect. This lagged structure allows teachers to adjust to wage shocks over time.
Putting equations [4] and [5] into [3] gives:

$$KS4_t = \sum_{k=1}^{5} \Pi_k \Big(\Big\{ \sum_{l=1}^{p} \lambda_l W_{t-5+k-l} \Big\} + S + \epsilon_{i,t-5+k} \Big) \tag{6}$$

For simplicity, we restrict the model so school level value added in a given school year is affected only by the wage the year before, so p=1 in equation [6]. The final exam result for the cohort at the end of their fifth year of secondary school at time t will then be:

$$KS4_t = \sum_{k=1}^{5} \Pi_k \Big\{ \lambda_1 W_{t-6+k} + S + \epsilon_{i,t-5+k} \Big\} \tag{7}$$

$$\implies KS4_t = \lambda_1 \sum_{k=1}^{5} \Pi_k W_{t-6+k} + \sum_{k=1}^{5} \Pi_k \Big\{ S + \epsilon_{i,t-5+k} \Big\} \tag{8}$$

It seems reasonable to place restrictions on the parameters so that early years contribute less to the final KS4 grade than later years. However, unless the restriction is that $\Pi_k = 0 \; \forall \; k \; \epsilon \{1, 4\}$, it is

[46] For notational purposes, we omit an additional subscript denoting the school.
[47] Where $n = t - 5 + m$.

clear that lagged values of the outside wage will affect KS4 exam performance. It is also clear that we will observe high serial correlation in KS4 results and highly serially correlated errors. Thus regressing KS4 exam results on the first lag on outside wages is unlikely to yield reliable results due to omitted variable bias and serial correlation.

In principle we could estimate (8). But it is difficult to identify all the coefficients on the lagged

Table A3: Wage dynamics and Serial Correlation

	Multiple lags		5 year moving average wage, all years	
	OLS	FE	OLS	FE
	[1]	[2]	[3]	[4]
$AverageWage$	-	-	-0.541***	-0.232
			(0.150)	(0.268)
$Outwage_{t-1}$	0.379***	0.395***	-	-
	(0.110)	(0.106)		
$Outwage_{t-2}$	-0.264**	-0.127	-	-
	(0.102)	(0.107)		
$Outwage_{t-3}$	0.130	0.135	-	-
	(0.094)	(0.104)		
$Outwage_{t-4}$	-0.056	-0.028	-	-
	(0.107)	(0.116)		
$Outwage_{t-5}$	-0.240**	-0.280***	-	-
	(0.116)	(0.119)		
$Outwage_{t-6}$	-0.481***	-0.471***	-	-
	(0.123)	(0.111)		
$\sum_{k=1}^{6} Outwage_{t-k}$	-0.532***	-0.375	-	-
	(0.168)	(0.343)		
SC Test AR(1)	z=-21.02	z=-33.6	-	-
	[0.000]	[0.000]		
SC Test AR(2)	z=0.98	z=3.67	-	-
	[0.329]	[0.000]		
SC Test AR(3)	z=-3.10	z=-5.73	-	-
	[0.002]	[0.000]		
SC Test AR(4)	z=-3.29	z=-5.43	-	-
	[0.001]	[0.000]		
No. Schools	3047	3047	3047	3047
N	18026	18026	18026	18026

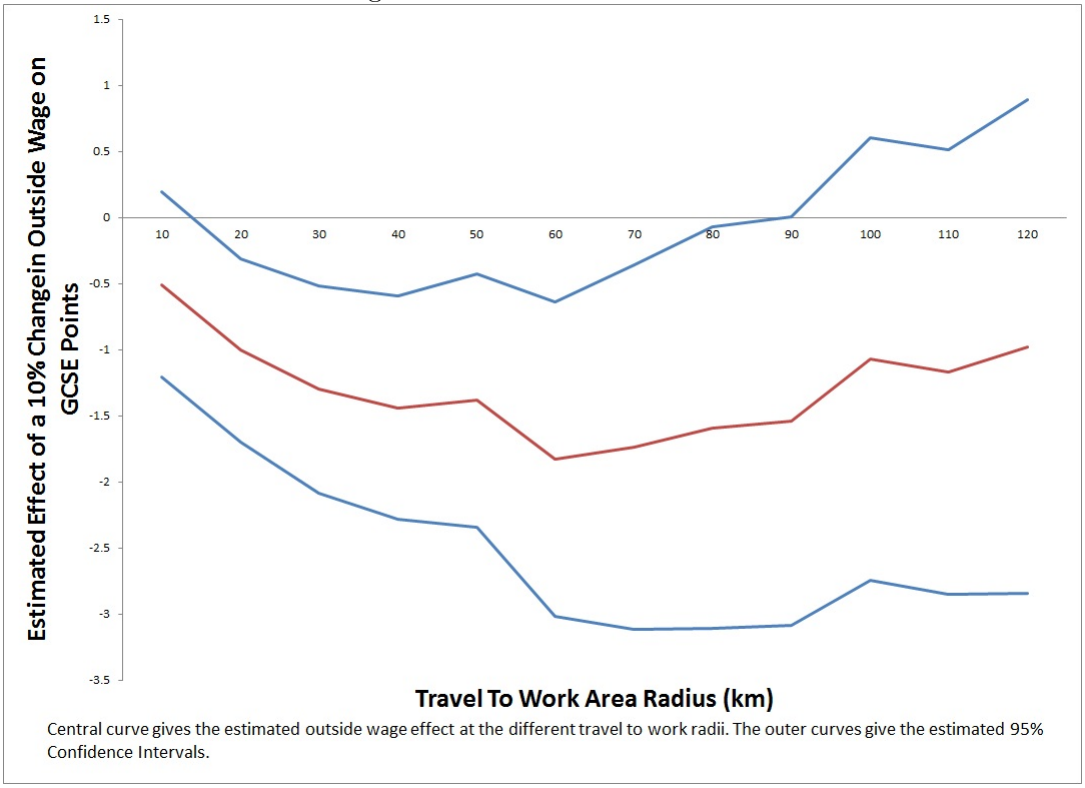
* = significant at the 10% level, ** = significant at the 5% level and *** = significant at the 1% level. P values for the SC tests are given in the parenthesis.

wages as these may evolve slowly. For the same reason, fixed effects estimates of (8) may not give good estimates of the individual wage effects. In our analysis we therefore assume common effects in lagged wages. However, here we estimate (8) directly in Table A3. Even if the estimate of each

specific lag is poor, if our hypothesis is correct, the sum of the coefficients should be negative. In columns (1) and (2) we show the estimates of (8). Column (1) presents the OLS estimates and column (2) the fixed effects estimates. Both columns show a negative effect of wages for several of the lags individually. At the bottom of each column we show the estimated average effect of all the lags. This is also negative for both OLS and fixed effects and significant in the OLS case. Below this we present tests for serial correlation which shows high levels of serial correlation in wages lagged upto 5 years. In columns (3) and (4) we present results using a 5 year moving average of wages. The coefficient estimates are negative and, in the case of OLS, well defined.

A.4 Travel to work Radii

Figure A4: Travel to work Radii



Central curve gives the estimated outside wage effect at the different travel to work radii. The outer curves give the estimated 95% Confidence Intervals.

A.5 High, Medium and Low Outside Wage Regions

In section 7, schools are divided into High, Medium and Low wage regions for investigation of heterogeneity and for Cost-Benefit Analysis calculations. Table A5 gives the average wages within each GOR in England (from ASHE) and averaged over the years 2005-2007 (there is very little sensitivity to the choice of years). Schools are allocated to a wage region depending on the relative ranking of the GOR in which they lie (for example all schools in the North East are allocated to the Low Wage Region).

Table A5: High, Medium and Low Outside Wage Regions

Government Office Region	Average Wage (£)	Wage Region
North East	29092	Low
Yorkshire & the Humber	30043	Low
West Midlands	30724	Low
East Midlands	30809	Low
North West	30941	Medium
South West	31330	Medium
East	34105	Medium
South East	37223	High
Inner London	37248	High
Outer London	49484	High

A.6 A Counterfactual Teacher Wages

The counterfactual teacher wage is intended to represent the alternative wage a teacher could earn in a region, were they not a teacher. We run the following regression separately for each of the three regions, using LFS data (we use only full time wages, and all ages from 24 to 60):

$$AnnualWage_i = \alpha + \beta NonTeacher_i + X_i'\gamma + \epsilon_i \tag{9}$$

We keep the three sets of fitted values and summarize for teachers to give the estimated average teacher wage in each region. The β coefficient then provides our estimate of the difference between the counterfactual teacher wage and the average teacher wage. We get estimated teacher wages of £36409, £33240 and £33263 and counterfactuals of £39469, £32776 and £31523 for the high, medium and low wage regions respectively. X is a vector containing a gender, ethnicity and highest qualification dummies.