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The teacher labour market, teacher turnover and disadvantaged schools: new evidence for England

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ABSTRACT

We study the market for teachers in England, in particular teacher turnover. We show that there is a positive raw association between the level of school disadvantage and the turnover rate of its teachers. This association diminishes as we control for school, pupil and local teacher labour market characteristics, but is not eliminated. The remaining association is largely accounted for by teacher characteristics, with the poorer schools hiring much younger teachers on average. We interpret this market equilibrium allocation as either deriving from the preferences of young teachers, or as reflecting the low market attractiveness of disadvantaged schools.

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1. Introduction

It is now well established that teacher effectiveness is central to good pupil progress in school.[1] Policies to improve overall teacher effectiveness and reduce educational inequality are hampered by a lack of understanding of the teacher labour market. While the 'macro' movements into and out of the profession as a whole are well researched in the UK, we know very little about the 'micro' movements into and out of schools. This matters for a number of reasons. First, it is school-level separations and engagements that schools see and react to; it may have implications for wages if schools pay more to attract staff, and for teacher workload if a school is over-stretched. Second, the balance of short and long tenures among teachers may affect the production function, including the possibility of lower attainment if pupils face a constant churn of their teachers (see for example, Ronfeldt et al. 2011). Research on this issue has simply not been possible on a large-scale representative basis due to a lack of data. Specifically, we address the view that teacher turnover is a particular problem for disadvantaged urban schools. It is argued that greater turnover coupled with the lower effectiveness of novice teachers might explain part of the substantial test score difference between schools in deprived and more affluent neighbourhoods. In fact, there is very little UK evidence on this issue,[2] rather more from the US that we briefly review below. Understanding the test score gap between disadvantaged pupils and the rest is a leading policy concern, contributing to low social mobility, so the potential role of teacher turnover is important.

In this paper we contribute to this evidence base by analysing teacher turnover across schools. We compute the distribution of job tenure[3] in each school, both the fraction of teachers who have been at the school for ten years or more, and the fraction only just hired. We first describe the distribution

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of job tenure for teachers. We then establish the nature and magnitude of the differential turnover between schools. We show that there are systematic differences in turnover: schools with many poor pupils do have more short-tenure teachers and fewer experienced teachers. However, on average the differences are small: 18% (22%) of teachers in the least (most) disadvantaged schools have tenure of 0–2 years, while 20% (17%) have tenure of over 10 years. We also use the richness of the data to decompose the relationship between turnover and poverty. We show that part can be accounted for by pupil characteristics, perhaps because students in schools in more deprived areas are harder to teach.

One particular focus of our analysis is spatial differences in the local teacher labour market around each school. These are likely to be important for turnover as there are clearly major differences in market density and hence job offer rates in urban and rural areas. The recent release of a new administrative dataset on teachers by the UK Department for Education offers great promise, and the fact that the data is a census of teachers means that we can model all the schools around a focus school, and so the overall local labour market conditions facing a teacher. Neighbourhood poverty is correlated with urban density, so we are able to show that local labour market conditions also explain part of the overall correlation between turnover and disadvantage.

The remaining association is largely accounted for by teacher characteristics, with the schools in disadvantaged communities hiring much younger teachers on average. We interpret this market equilibrium allocation as either deriving from the preferences of young teachers, or as reflecting the low market attractiveness of disadvantaged schools. Teachers are not randomly assigned to schools but are hired through a search and matching process. While the relationships we estimate cannot be given a watertight causal interpretation, our results have an IV interpretation and we see the results here as providing the first detailed description of teacher turnover in England.

Research on teacher turnover in the UK has been hampered by the lack of data, and a consequently greater reliance on turnover intentions than might otherwise be desirable. The literature has also used different concepts in addition to the separation rate with a focus on the 'wastage' rate, i.e. the fraction of teachers leaving the profession entirely.

The available evidence suggests an association between higher turnover and schools serving disadvantaged students, although the evidence base is not extensive in England. Dolton and Newson (2003) find that 10% more students eligible for free-school meals (FSM) is associated with 1% higher teacher turnover. The teacher labour market is different in many ways between England and the US, not least that schools are the employer in England as opposed to school districts in the US, and school pay is correlated with school context in the US but not in the UK. Nevertheless, given the paucity of UK evidence, a brief review of US evidence is useful. Boyd et al. (2011) use NYC administrative data on the applications-to-transfer for the years 2006–07 and 2007–08 and finds that schools with higher proportions of Black, Hispanic, low-income and low-achieving students receive about 40% fewer applicants to them and about 40% more away from them. Similarly Ronfeldt et al. (2011) find that schools with least turnover have more high-achieving and Asian students, fewer poor, Black and Hispanic students, and fewer student absences and suspensions. Hanushek, Kain, and Rivkin (2004) find that almost 20% of teachers in the bottom quartile of schools, ranked by student achievement, leave each year as opposed to 15% in the top quartile schools. Boyd et al. (2008) show that among first-year teachers, the less effective (based on a value-added estimate) are more likely to leave, though this correlation disappears in the subsequent few years. Loeb, Kalogrides, and Béteille (2011) study the hiring, deployment and retention of effective teachers and find that effective schools are better able to retain effective teachers. Interestingly, Falch and Ronning (2007) find the opposite correlation between turnover and disadvantage in Norwegian schools.

Section 2 sets out the statistical and economic framework we use to interpret the results, and section 3 describes the data. Section 4 establishes the nature of the relationship between disadvantage and turnover, and section 5 analyses the source of that association. Finally, section 6 summarises the results and estimates the impact of the higher turnover on school performance.

2. Economic and statistical modelling of the tenure distribution

2.1. Theoretical framework

We first discuss individual behaviour and then market equilibrium. Total separations from a school combine quits, retirements and layoffs. In fact, very few teachers are dismissed in England, so we ignore that. Retirements obviously do happen and will form part of the separations at older ages, but the emphasis here is on quits. Teachers can leave their current school to work in another school, in another job outside teaching or to leave the labour force altogether. Standard models of quits emphasise wage offers, promotion or wage growth prospects, and non-pecuniary aspects of a job. In teaching, although wage schedules are very important, there is still important variation in pay for teachers with the same role, age[4] and qualifications, albeit much less than in the private sector. The SD of pay relative to mean pay for teachers[5] who are aged 23–25 is 0.153; 0.189 for those aged 33–35, 0.210 for those 43–45, and 0.160 for those aged 53–55. Wage growth and promotion prospects also vary, particularly with school size. Non-pecuniary aspects of different schools are likely to be very important given the relative fixity of public sector pay scales compared to private sector employers. These will include the characteristics of the students, and the general 'teach-ability' of the student body; the resources available to the school, for example the provision of IT and the availability of teaching assistants; and the ethos and management of the school. Some of these factors may only become apparent after starting in the job, but many including the level of disadvantage will be very evident at the job interview.

Teachers are not distributed at random across schools of differing degrees of disadvantage, so it is not possible to give the findings we present below a strong causal interpretation. Specific types of teachers are hired into specific types of school, and their subsequent separation decisions are part of the expected outcome at the point of hiring. So to interpret our results we need to characterise the market equilibrium, most appropriately studied using a search and matching approach. The central reference is Shimer and Smith (2000) laying out a model of search and assortative matching that has many of the features required here. More recently Lise, Meghir, and Robin (2013) have begun the process of solving a richer model.

To be clear, because of the complexity of modelling such two-sided search and matching markets, neither of these papers directly and fully models this market, so the characterisation set out below is a sketch extrapolating from the richest models currently available.

Suppose teachers differ along one dimension, possibly only imprecisely observable beforehand ('effectiveness', denoted E) and that schools similarly differ in the 'agreeable-ness' (A) of their students. This is a market with inflexible wages so wages cannot fully reflect these observable differences. The market will work as follows if both teachers and schools have fixed and equal preferences over A and E respectively, so all teachers agree on the ranking of desirable schools and all schools agree on the ranking of desirable teachers. The market equilibrium will see the high E teachers matched with the high A schools; depending on the set-up and parameters of the model they may continue job search, but at a low intensity. The lower E teachers will tend to be matched with lower A schools, and will engage in higher intensity job search. If there is sufficient exogenous turnover in the model to create new job slots, and if pre-hire estimates of A and E are sufficiently poor to give low E teachers a chance at a better A school, then this set-up will yield the prediction of greater quits out of (and hires into) low A schools. So low E teachers accept jobs in low A schools and continue job search, simply because it is better than searching whilst unemployed, intending and expecting to stay there not very long. The extent of differential separations out of high and low A schools is likely to depend on the precision of pre-hire measures of A and E, the degree of flexibility of wages and on the degree of exogenous turnover.

It is hard to argue that teachers would quit disadvantaged schools because the degree of disadvantage was a surprise. However, it could be that some novice teaches are surprised by how hard it is to deal with the challenges arising in disadvantaged schools. It could be that their preferences over

A change, or it could be that it was an optimal strategy for them to accept the job temporarily and continue employed job search.

A number of things follow from this interpretation. First, a high level of disadvantage at a school gives rise to higher separation rates only indirectly, as it means that teachers will continue with job search and thus be more likely to leave. Second, any performance penalty that such schools suffer will derive from the fact that they are only able to hire relatively ineffective teachers,[6] as well as any further detrimental effect from the turnover of teachers *per se*. Thirdly, there are likely to be further equilibrium effects too. The low productivity of teachers hired to low A schools will produce poor academic results and hence we would expect better-off families to select away from them. To a degree we deal with this by using measures of neighbourhood disadvantage rather than the actual students admitted.

This exposition focuses on schools' attributes and teacher effectiveness to sketch out a model of an equilibrium allocation of teachers to schools. While we have very rich data on schools and pupils, and on a number of characteristics of teachers, the available data in England does not individually link teachers to pupils and so (unlike Boyd et al. (2011) and Loeb, Kalogrides, and Béteille (2011)) we cannot estimate teacher level measures of effectiveness.

Finally, it is worth noting that education authorities are aware of recruitment problems in some schools. Incentives for teachers in specific subjects are now considerable, for example 'Top graduates are being offered up to £30,000 tax free to train to teach the key subjects'.[7] Jobs in specific schools facing recruitment difficulties offer inducements beyond salary such as health insurance.[8] Such schemes clearly fit within the framework we have set out above as influencing the marginal job acceptance decision.

2.2. Methodology

Our aim in this paper is to establish the nature of the relationship between teacher turnover and school disadvantage. Second, we analyse what factors 'account' for the correlation by sequentially adding a series of controls for different aspects of the school and its environment to see whether they account for the variation. First, we add to the baseline model the structural characteristics of the school, such as location, size and so on; second, we include the characteristics of the pupils admitted to the school. Third, we add characteristics of the local teacher labour market around the focus school. High poverty schools tend to be in city centres and hence in thick markets generating more job offers. It may be that this explains the higher turnover rate in such schools. Finally, we include the characteristics of the teachers themselves. This has to be interpreted carefully given the discussion above. Schools hire the teachers they can, so hiring teachers with particular characteristics is the school's optimal response to their circumstances, not an exogenous factor imposed on them. So it is the mechanism through which higher turnover arises, not the cause of the higher turnover itself.

Since we do not have a strongly exogenous source of variation in disadvantage, we do not claim that this relationship is simply the causal impact of poverty on turnover. There are two potential sources of endogeneity. The reverse causation story is that high teacher turnover reduces school performance, leading more affluent parents to avoid that school.

To mitigate the effect of this we use a measure of neighbourhood disadvantage around the school rather than the current fraction of poor students in the school. This could also be interpreted as an IV strategy. That is, we could use the neighbourhood poverty rate around a school as an instrument for the school poverty rate. While the existence of considerable school choice means that the neighbourhood poverty rate is likely to be affected much less by school performance than the actual composition of the school, we do not push this interpretation. Running the IV estimation yields very similar results to those presented here (results available from the authors).

Another argument for endogeneity is the presence of correlated unobserved characteristics. A number of the relevant characteristics in the teacher-school match are important for that match

and are not well measured. The rich data that we have on pupils, schools, and neighbourhoods means that we probably do a reasonable job of capturing school heterogeneity.

2.3. Statistical modelling

Our framework has two components, understanding the relationship between elapsed tenure (our data) and completed tenure, and then between completed tenure and the separation rate.

Our data are a sample of teachers currently employed, so we necessarily have a distribution of elapsed tenure: how long each teacher has been in their job so far. At an individual level, a specific teacher may leave the day after the survey, or stay for another ten years. However, over the data as a whole, there is a relationship between elapsed and completed tenure. The link is provided by renewal theory (see Lancaster 1990). Suppose completed tenure, τ, has pdf $g(\tau)$ with mean μ, then the pdf of elapsed tenure, ε, is $f(\varepsilon) = [1 - G(\varepsilon)/\mu$. For individuals for whom the turnover process has been running a long time, the pdf of remaining tenure is the same as the pdf of elapsed tenure: expected completed tenure is equal to two times the elapsed tenure. To be clear, all we need to assume in our analysis is that elapsed tenure is a good predictor for completed tenure, we do not need a steady-state assumption.

The distribution of completed job tenure is closely related to the separation rate.[9] In a simple case of a constant separation rate over tenure and in steady state, the expected length of job tenure is equal to one over the separation rate; for example, a constant separation rate of 10% per year gives an expected completed tenure of 10 years. In a more general model, the situation is more complex. For one individual in a job, her tenure depends only on her own separation probability. But the distribution of tenure in an organisation depends in general on all the tenure-specific separation rates and on the hiring rate (Bartholomew 1982). In steady-state, it depends only on the separation rates, but out of steady-state, it depends on hiring too. It is easy to see why: if an organisation is growing and experiences a burst of hiring, there will temporarily be a disproportionate number of people with very short tenures.

2.4. Institutional structure – the assignment of new teachers

Part of the flow of new hires into schools will be accounted for by new teachers who have just finished their initial training. Whilst not yet fully qualified, the hiring process for such teachers is very similar to that for established teachers. Unlike many other countries, there is no centralised allocation of new teachers, and jobs and workers are matched largely as they are in any standard labour market. One difference is that teachers will have spent time working in their training schools, and this 'extended interview' generates private information for that particular school, affecting the chances of a job offer. Depending on the specific initial training route taken, this in-school teaching practice will be shorter or longer, but given the established findings on the unpredictability of teacher effectiveness (reviewed in Burgess 2016), this private information will be valuable to schools.

3. Data

Our analysis combines three datasets: the first full collection of the School Workforce Census (SWC), the National Pupil Database (NPD) and Edubase, giving school characteristics. We categorise all schools as either primary or secondary using the DfE-standard approach for non-standard entry schools. All special schools and nursery schools are excluded from the analysis.

3.1. School workforce census

The School Workforce Census (SWC) is individual-role level data on all staff from local authorities, state-maintained schools and academies in England. The census is run by the Department for

Education, with the first full sweep taking place on 4th November 2010. It is a statutory requirement on schools and local authorities (LAs) to submit the SWC return, with data being supplied from either schools or LAs, or a combination of the two. In the majority of LAs, data is sourced from schools, but where possible, some LAs provide all or most of the data (although schools may still be asked to check the data). Validation of the returns is carried out by the LA, with the exception of Academies and City Technical Colleges (CTCs), who approve their own returns.

The unit of observation is an individual-role, so it is possible for an individual who has, for example, one part-time contract as a lunchtime supervisor and another part-time contract as a classroom teacher to have two observations in the data. Similarly, an individual may also have two data entries if they are contracted as both a classroom teacher and Head of Department.

The full SWC initially has 1,292,494 observations from 21,423 primary and secondary schools including information on over 400,000 teachers and 270,000 teaching assistants. The census includes contract information such as the start date, hours worked, annual pay and all roles an individual has within a school (teacher, head of department, lunch time supervisor etc.), as well as an indicator for whether the member of staff is employed by the local authority or the school they are working at. It also includes personal characteristics such as date of birth, gender and ethnicity, an indicator of whether a teacher has attained qualified teacher status (QTS), information on subject studied and the level of qualification (degree, PGCE etc.), as well as on the amount of time spent in the classroom teaching each subject.

There are two data quality problems with SWC: missingness on particular variables and apparently missing observations. Missingness on variables is a particular problem for indicators such as subjects taught in the classroom (68% missing) and teacher qualifications, for example Qualified Teacher Status (QTS) route. Since this does not have to be back-filled for staff that already have QTS, it is missing for 78% of observations. Secondly, the very large variation in staff-pupil ratios across schools lead us to suspect that some schools have failed to submit a return for every member of staff and this should be borne in mind during the analysis section. However, our results still stand when excluding those schools that have a staff-pupil ratio of less than 0.02.

In order to focus on teacher turnover, we restrict our sample to classroom teachers, excluding anyone defined as support staff and teaching assistants.[10] Since most of the data on agency or service agreement teachers is missing, we also drop them, as well as those teachers who teach less than half a day (three hours per week). Then, by using worker ID, we are able to merge together roles into one observation per person. This leaves us with a sample of 343,547 people who identify themselves as a 'classroom teacher'.

Table 1 presents some descriptive statistics from this sample. Primary school teachers are on average younger than their secondary school counterparts. The vast majority of teachers are of white ethnicity and hold either a degree or higher, BEd or PGCE.

We use the SWC to create a series of teacher and school level characteristics, and also estimate a school-level pay premium as the school fixed effect in a teacher pay regression that controls for years of tenure, gender, age (including interaction terms), ethnicity and whether part-time. In our analysis we simply use a binary indicator of whether the pay premium in a teacher's school is greater than zero.

3.2. Summarising the tenure data

We focus on the distribution of elapsed tenure, how long a teacher has been in the job so far. Note that in a survey of current teachers, elapsed tenure is all that can ever be measured. We calculate tenure by using the date of arrival in school. The SWC guidance defines this as follows:

> *"This shows when a member of staff began their current period of continuous service at their current school … Long term absences, whether for sickness, maternity or paternity, should not cause this date to change neither should factors such as spine point progression or passing the threshold. However, a career break, which might be an extension of maternity leave, would be followed by a new date.*

Table 1. Teacher numbers and characteristics.

	---Primary---	---Secondary---
Gender		
Male	*11.1*	*35.9*
Female	*88.9*	*64.1*
Age category		
Age <= 30	28.9	29.1
30 < Age <= 50	51.7	51.0
Age > 50	19.4	19.9
Highest qualification		
Degree or higher	62.6	78.2
Bed	21.4	7.4
PGCE	2.8	3.4
Other qualification	6.1	3.2
Ethnicity		
Asian excl Chinese ethnicity	2.7	3.6
Black ethnicity	1.3	2.5
Other incl Chinese ethnicity	0.9	1.1
White ethnicity	91.6	87.6
N	171,410	172,137

Note: Classroom teachers only.

Date of Arrival in School should be provided for all teachers and teaching assistants that started their current period of continuous service with the school during the previous academic year, i.e. from 1 September 2009. For staff that began their current period of continuous service some time ago, it may not be possible to accurately provide this information. If this is the case the Department would prefer no date to be entered.'

Despite the SWC guidance, there is no major problem of missingness with dates of arrival in school.

However, there is an issue of heaping in the data. This is because most hires start on a specific date (1st September), 64 days from the Census date, so there are local peaks in the distribution at 64 days and multiples of 64 thereafter (i.e. 429 = 64 + 365). Therefore, with the creation of the tenure bands, we account for the heaping by shifting the bands by 64 days. We use the following categories as our dependent variables:

- 'hired 0–2 years' includes those teachers who have been at the school for less than or equal to 429 days;
- 'hired 2–5 years' includes those who have been at the school more than 429 days, but less than or equal to 1890 days
- 'hired 5–10 years' includes those who have been at the school more than 1890 days, but less than or equal to 3716 days
- 'hired 10 years or more' includes those who have been at the school at least 3716 days

Table 2 presents summary statistics on tenure. Looking at all teachers, on average 7.5% were hired in the present year, and 8% of currently employed teachers were hired the previous year. Because this is a stock sample of currently employed teachers, we must be cautious about saying that the hiring rate last year was 8% because some of those hired will have left. Looking across the tenure categories, overall 20% of teachers have been in their current school for less than two years, and just over half have an elapsed tenure of less than five years. At the other end of the tenure distribution, nearly 20% have been in their present school for over 10 years, and in fact over 5% have stayed over 20 years. Mean tenure is 6.7 years.

The data show only minor gender differences in tenure, with women very slightly more heavily represented in the longer tenure categories. Mean tenure is 6.6 years for women and 6.8 years for men. There is also very little overall difference in the job tenure distribution between primary and

Table 2. Tenure descriptive statistics.

	All teachers	Male	Female	Primary	Secondary	Full-time	Part-time	Age<=30	30 < age < 50	Age > 50	London	Non-London
Average elapsed tenure (years)	6.7	6.8	6.6	6.5	6.9	6.6	6.8	6.2	6.7	7.3	5.8	6.9
Tenure distribution (%)												
0–2 years	19.4	20.4	19.2	19.5	19.4	21.6	12.4	37.9	14.1	6.3	23.5	18.7
Of which hired this year	*7.5*	*7.9*	*7.4*	*7.7*	*7.3*	*8.6*	*4.2*	*15.6*	*5.2*	*1.8*	*9.1*	*7.3*
2–5 years	36.8	37.0	36.7	36.6	37.0	38.7	30.7	51.6	35.7	18.0	38.7	36.5
5–10 years	24.8	23.5	25.2	24.8	24.8	22.7	31.5	10.4	32.6	25.6	23.0	25.2
10 years or more	18.9	19.1	18.9	19.1	18.8	16.9	25.4	0.0	17.7	50.1	14.9	19.7
N	343,547	80,704	262,843	172,137	171,410	262,020	81,527	99,564	176,457	67,526	53,434	290,113

Note: Classroom teachers.

secondary school teachers. There are more substantial differences by part-time status, part-time teachers having spent much longer in their current schools.

Appendix Figure 1 displays the kernel density function of tenure days for teachers in primary and secondary schools, and clearly illustrates the heaping of the data at annual intervals.

These are new data, and it would be useful to compare these results to previous studies. However, most of the existing UK studies focus on the rates at teachers leave the profession (the 'wastage' rate) rather than the separation rate. Barmby (2006) surveys 246 teachers in England and Wales to estimate a teacher wastage rate of 9.3% in England for the year 2000–01. He also finds that 26.8% of teachers in the sample were considering leaving teaching in the next 5 years. This is broadly in line with Tracey et al. (2008), showing that 3% of the teachers surveyed said that they expected to leave the profession in 3 years' time, and 10% expected to move to a different school in the following year. In the UK, Dolton and van der Klauww (1995) use the Department of Employment survey from 1987 and find a turnover rate of 37% over 6.5 years (where turnover is defined as exits out of teaching i.e. wastage). In other countries, turnover rate estimates include values of 13% to 25% for the US (Ingersoll 2001; Boe, Cook, and Sunderland 2008; Harris and Adams 2007), and 9% for Norway (Falch and Ronning 2007).

Comparing the sub-populations, Boe, Bobbitt, and Cook (1997) also report no real difference in turnover rates between phases of education, although Stuit and Smith (2009) find a higher separation rate in secondary schools. There is also evidence that turnover rates differ by gender (Grissmer and Kirby 1987; Ingersoll 2001) though more recently Hutchings (2011) finds that the gender gap in those leaving the profession altogether has become insignificant. There is evidence that part-time teachers have a higher turnover than full-time teachers (Boe, Shin, and Cook 2007), which is rather different from the results here. There is a good deal of evidence showing that young or less experienced teachers have a higher turnover rate than older or more experienced teachers (Loeb, Kalogrides, and Béteille 2011; Krieg 2006; Zabalza 1978; Smithers and Robinson 2003, Boe, Shin, and Cook (2007), Hanushek, Kain, and Rivkin (2004)). At the level of the whole profession, Dolton and van der Klauww (1995) find that the hazard rate of leaving teaching entirely exhibits positive duration dependence.

3.3. National pupil database (NPD) and edubase

The NPD is an administrative database covering all pupils in state-maintained schools in England. NPD contains pupil demographics such as gender, within-year age, and ethnicity, and test score histories. The data also include indicators of whether English is the pupil's mother tongue, and whether the pupil has special educational needs. Pupil characteristics are averaged to produce school-level descriptors.

We have two potential measures of poverty. Eligibility for free school meals (FSM) is based on eligibility for welfare benefits and is a reasonably good indicator of poverty (see Hobbs and Vignoles 2007). The pupil's home address is tagged with an index of deprivation, the Index of Deprivation Affecting Children Index (IDACI), which gives a good measure of neighbourhood deprivation.

Edubase provides an administrative record for all schools, whether maintained or private, in England, which provides the structural characteristics of each school: region indicators (with additional indicators for the Inner, Outer and Fringe London pay regions); urban/rural indicators; school age span (highest and lowest ages of pupils); school governance type and whether it is a single-sex, grammar or boarding school; the number of full-time equivalent pupils and also the official school capacity; nursery school presence indicator and size; and sixth form indicator and size.

3.4. Geographies

We are concerned with two key spatial constructs: the teacher labour market and the school catchment area.

Our key explanatory variable is neighbourhood deprivation, and this is built up from the de facto school catchment area based on Lower Layer Super Output Areas (LLSOA). LLSOAs are a geographic hierarchy built from groups of contiguous Output Areas. They are generated to be as consistent in population size as possible, and typically contain from four to six Output Areas. The minimum population is 1000 and the mean is 1500. Since we know the postcodes of the pupils at the school, we can define the pupil catchment area as all the Lower Layer Super Output Areas from which pupils are drawn. Thus neighbourhood poverty is calculated by taking an unweighted average IDACI score of all the local neighbourhoods that the school draws from; this is in general all the local neighbourhoods. This differs from the straightforward school IDACI score which simply averages over the pupils which actually attend the school. We use the neighbourhood measure as this derives solely from where the school is situated rather than its actual admissions, and so can be considered as exogenous to school policies, and unobserved school and teacher characteristics.

We assume that the local teacher labour market extends to a maximum radius of 30 km around the teacher's current school.[11] This is obviously ad hoc but is reasonable given data on average commute lengths (Dent and Bond 2008, calculate the average commute to be 13 km). We take the number of other schools (of the same phase of education) within the radius as a measure of the density of the market. The search and matching approach shows that, other things equal, a thick market will generate more alternative job offers and thus make quitting more likely. We distinguish high, average and low market density.[12] There is a clear correlation with neighbourhood poverty: the high levels of market density are disproportionately in poorer areas.

We also include indicators which capture the difference between the focus school and its competitors in the local labour market. These are: whether the school has a higher percentage of students eligible for FSM than the average in the local labour market; whether the mean competitor pay premium is greater than zero; and whether the mean competitor pupil growth rate is greater than zero.

4. Results 1: do disadvantaged schools experience high teacher turnover?

We first describe the relationship of poverty with teacher turnover, before considering the source of the correlation.

We present this information graphically, focussing on two cuts of the tenure distribution: teachers whose tenure is less than two years, and teachers with tenure greater than ten years. Figure 1 shows how the percentage of teachers with tenure less than two years varies with school poverty. As noted above, we are using neighbourhood IDACI to provide the measure of school disadvantage. Because of the overwhelming importance of age for tenure, we do this separately for three age categories: aged under than 30; aged from 30 to 50; and aged over 50; we also split schools into primary and secondary phases. The graph shows 50 quantiles of neighbourhood IDACI, with higher numbers indicating higher levels of poverty. Other than secondary school teachers aged less than 30, we observe a positive correlation between neighbourhood IDACI and the proportion of teachers with short tenures: schools situated in disadvantaged neighbourhoods have a higher proportion of new, potentially less experienced, teachers. There is not much difference in the pattern across the age groups, although the strongest correlation appears in teachers aged over 50.

Given the pattern in the previous set of graphs, we might expect a negative correlation between neighbourhood IDACI and the proportion of teachers with tenure of more than ten years. Figure 2 shows that while this is the case for secondary schools, it is not for primary schools. In secondary schools, the percentage of teachers with tenure of more than ten years is negatively correlated with neighbourhood IDACI. The opposite is true for primary school teachers. In other words, secondary schools situated in deprived neighbourhoods have a lower proportion of long-standing teachers.

Figure 3 takes a different cut through the data and shows quantiles of the distribution of tenure. Each vertical slice of the graph shows the 10th, 25th, 50th and 75th‰ of tenure against the neighbourhood IDACI score (each slice represents 2% of schools). The graph shows that there is little

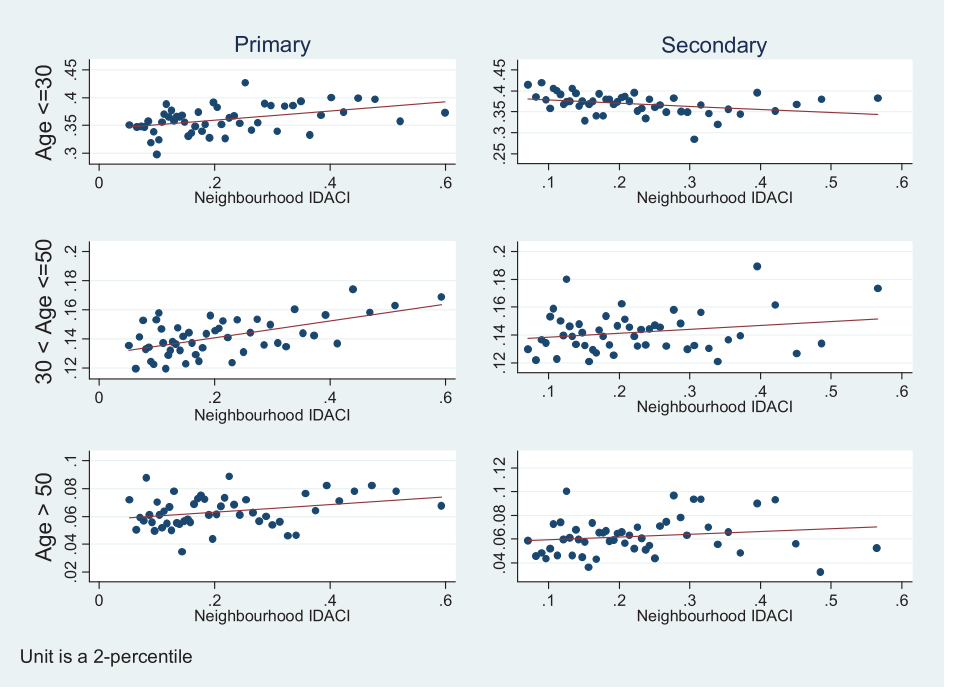

Figure 1. % Tenure 0–2 years.

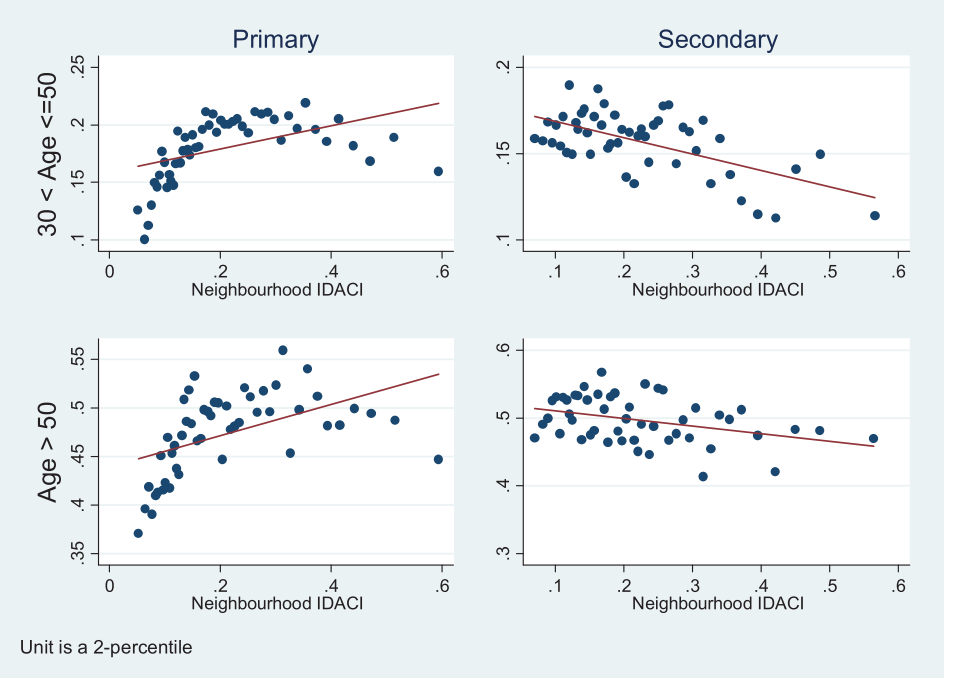

Figure 2. % Tenure 10+ years.

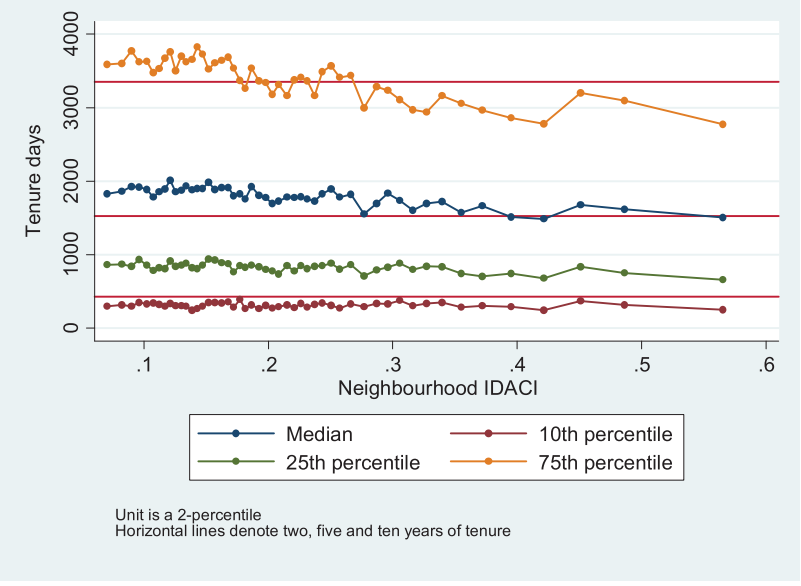

Figure 3. Elapsed tenure by neighbourhood IDACI.

difference in short tenures across schools, and that there is a decline in longer tenures at schools in poor neighbourhoods.

We postpone a discussion of the quantitative significance of the relationship until later.

5. Results 2: analysis of the school tenure distribution

What is it about poor schools and neighbourhoods that is associated with high turnover? The following set of regressions start with a very simple model, and progressively add more explanatory variables to see which if any characteristics 'account' for the correlation. We consider school characteristics, pupil characteristics, the nature of the local teacher labour market, and finally the characteristics of the teachers that the schools hired.

In each of the following series of regressions[13] we consider three dependent variables separately for primary schools, in Table 3, and secondary schools, in Table 4. These are the school fraction of teachers with tenure less than two years, the fraction with tenure greater than ten years, and mean elapsed tenure. These are school-level regressions, with a school as the unit of observation.

The base regression controls for a few school characteristics[14]: the number of full time equivalent pupils, sixth form dummy and regional and urban dummies. As explained above, we also need to control for schools being 'out-of-steady-state', and to do this we include the 2007–2009 average growth in pupil numbers in all the regressions. The key variable of course is the neighbourhood poverty rate, and we include this flexibly to allow for non-linearities.

As expected, the results largely reflect Figures 1 and 2: higher neighbourhood deprivation is associated with higher teacher turnover. In terms of the other (non-displayed) coefficients, the main finding is that in accordance with Smithers and Robinson (2003), we find that teacher turnover is higher in London. Our results also show that turnover is lower in larger schools.

A primary school with a neighbourhood IDACI score in the highest bracket has 2.8% points more teachers with short elapsed tenures, relative to a value of 17.1% in the least disadvantaged schools. For the most deprived secondary schools, the short tenure group is 2.3% points higher, relative to the mean in the most affluent groups of 18.3%. The fraction of highly experienced teaching staff (tenure greater than 10 years) is 1% point lower in primary schools (relative to 18.8%), and 5.5% points lower

Table 3. Regression analysis of poverty and teacher turnover – primary schools.

	0.15 < Neighbourhood IDACI <= 0.2		0.2 < Neighbourhood IDACI <= 0.3		Neighbourhood IDACI > 0.3		
	Beta	SE	Beta	SE	Beta	SE	R-squared
TENURE 0–2 YEARS:							
Base case	0.010**	0.004	0.033***	0.004	0.028***	0.004	0.083
With pupil characteristics	0.010**	0.004	0.031***	0.004	0.022***	0.004	0.085
With pupil and market characteristics	0.007*	0.004	0.024***	0.005	0.013***	0.005	0.087
With pupil, market and teacher characteristics	0.001	0.004	0.011***	0.004	0.004	0.004	0.243
TENURE 10+ YEARS:							
Base case	−0.001	0.004	−0.016***	0.004	−0.010**	0.004	0.176
With pupil characteristics	0	0.004	−0.012***	0.004	0	0.004	0.181
With pupil and market characteristics	0.001	0.004	−0.007*	0.004	0.007	0.005	0.192
With pupil, market and teacher characteristics	0.008**	0.004	0.003	0.004	0.013***	0.004	0.374
AVERAGE ELAPSED TENURE:							
Base case	−0.084	0.070	−0.357***	0.070	−0.329**	0.068	0.175
With pupil characteristics	−0.065	0.070	−0.287***	0.070	−0.147**	0.072	0.181
With pupil and market characteristics	−0.029	0.070	−0.181**	0.072	0.005	0.076	0.191
With pupil, market and teacher characteristics	0.109*	0.059	0.041	0.060	0.154**	0.063	0.451

Notes: Unit of observation is a school. The first two regressions in each set have 16,268 observations; the other regressions have 16,267 observations.

Each row is a regression, only reporting the coefficients on the IDACI variables relative to the omitted category of low IDACI (IDACI <= 0.15).

Dependent variables are: the proportion of teachers with tenure 0–2 years, the proportion of teachers 10+ years; average elapsed tenure.

*indicates significant at 10%, ** indicates significant at 5%, *** indicates significant at 1%.

Variables included in all regressions are: pupil growth rate, school size dummies, sixth form, inner/outer London pay regions, local authority and urban dummies.

Pupil characteristics are: ethnicity, proportion of female students, SEN status and EAL status.

Market characteristics included: school pay premium, market density dummies, and competitor pay premium, pupil growth rate and %FSM dummies.

Teacher characteristics are: age, gender, age/gender interaction terms, ethnicity, full-time/part-time dummy and shortage/surplus subject dummy.

in secondary schools (relative to 20.6%). Unsurprisingly, average tenure is also lower in the most deprived primary and secondary schools, by about a third of a year in primary schools and a year in secondary schools.

5.1. The role of pupil characteristics

The base regression is built on by introducing school average pupil characteristics as independent variables. These are the proportion of pupils with special educational needs (SEN), the proportion with English as an additional language (EAL), the ethnic composition of the pupil body, and the proportion of female students.[15] As expected, some of these characteristics are significant. Consistent with Smithers and Robinson (2004), we find that turnover is higher in schools with a greater proportion of pupils with SEN. In secondary schools, a greater proportion of students with EAL is associated with higher teacher turnover. In terms of pupil ethnicity, our results support Ronfeldt et al. (2011) in finding that schools with lower turnover generally have more white and Asian students.

More importantly, we still find neighbourhood deprivation to be statistically significant. For example, the coefficient on the highest disadvantage group on the 0–2 years of tenure has declined from 0.028 to 0.022 for primary schools, and remained unchanged at 0.023 for secondary schools. Thus pupil characteristics explain little of the relationship between neighbourhood deprivation and teacher turnover. Pupil characteristics explain a little more of mean elapsed tenure, about a quarter of the effect in primary schools and slightly less in secondary schools. The differences reflect movement within and between the two cuts of the distribution we focus on, novices and experienced teachers.

Table 4. Regression analysis of poverty and teacher turnover – secondary schools.

	0.15 < Neighbourhood IDACI <= 0.2		0.2 < Neighbourhood IDACI <= 0.3		Neighbourhood IDACI > 0.3		
	Beta	SE	Beta	SE	Beta	SE	R-squared
TENURE 0–2 YEARS:							
Base case	0	0.005	0.018***	0.006	0.023***	0.007	0.187
With pupil characteristics	0.001	0.006	0.018***	0.006	0.023***	0.007	0.189
With pupil and market characteristics	0.001	0.006	0.018***	0.006	0.022***	0.007	0.192
With pupil, market and teacher characteristics	−0.006	0.005	0.005	0.005	0.006	0.007	0.340
TENURE 10+ YEARS:							
Base case	−0.016***	0.005	−0.035***	0.006	−0.055***	0.007	0.321
With pupil characteristics	−0.014***	0.005	−0.030***	0.006	−0.044***	0.007	0.332
With pupil and market characteristics	−0.013**	0.005	−0.027***	0.006	−0.036***	0.007	0.336
With pupil, market and teacher characteristics	−0.003	0.004	−0.009*	0.005	−0.016***	0.006	0.540
AVERAGE ELAPSED TENURE:							
Base case	−0.320***	0.102	−0.662***	0.110	−1.032***	0.133	0.286
With pupil characteristics	−0.285***	0.102	−0.573***	0.113	−0.842**	0.145	0.295
With pupil and market characteristics	−0.274***	0.102	−0.508***	0.116	−0.707***	0.151	0.298
With pupil, market and teacher characteristics	−0.059	0.080	−0.144	0.090	−0.283**	0.118	0.575

Notes: Unit of observation is a school. The first two regressions in each set have 2,770 observations; the other regressions have 2769 observations.

Each row is a regression, only reporting the coefficients on the IDACI variables relative to the omitted category of low IDACI (IDACI <= 0.15).

Dependent variables are: the proportion of teachers with tenure 0–2 years, the proportion of teachers 10+ years; average elapsed tenure.

*indicates significant at 10%, ** indicates significant at 5%, ***indicates significant at 1%.

Variables included in all regressions are: pupil growth rate, school size dummies, sixth form, inner/outer London pay regions, local authority and urban dummies.

Pupil characteristics are: ethnicity, proportion of female students, SEN status and EAL status.

Market characteristics included: school pay premium, market density dummies, and competitor pay premium, pupil growth rate and %FSM dummies.

Teacher characteristics are: age, gender, age/gender interaction terms, ethnicity, full-time/part-time dummy and shortage/surplus subject dummy.

5.2. The role of the local teacher labour market

The characteristics of the local teacher labour market are added as independent variables, in order to capture thick market and competition effects. These characteristics are market density, the focus school's estimated pay premium, dummies for the competitor's estimated pay premia, %FSM and the growth rate in pupil numbers. The ability to generate such data is one of the big advantages of census data such as the SWC. Obviously, there is a great deal more that can be done using these local teacher labour markets, which we intend to follow up in subsequent papers.

The focus school's pay premium is negatively associated with turnover, as one might expect.[16] We also find that a school experiences higher turnover if the fraction of its students eligible for FSM is higher than its competitors in the teacher labour market. This speaks quite directly to an association between turnover and deprivation. Market density is significant for the long tenure categories in the expected direction: primary schools with fewer competitors have 1.3% points more teachers with long tenures. Similarly, for secondary schools in thin markets, the long tenure group is 2.6% points higher.

Our central focus is the neighbourhood deprivation results and they remain significant, though reduced from the base case and inclusion of pupil characteristics. Primary schools with a neighbourhood IDACI score in the highest bracket have 1.3% points more teachers with short tenures, relative to a value of 17.1% in the least disadvantaged schools, so 7.6% higher. For the most deprived secondary schools, the short tenure group is 2.2% points higher, relative to the mean in the most affluent groups of 18.3%. Similarly, the relationship between mean tenure and deprivation also reduces in size.

5.3. The role of teacher characteristics

Finally, teacher characteristics are added to the regressions: age, gender, gender*age interactions, shortage/surplus subject dummy, ethnicity and whether working full-time.

As noted above, the interpretation of these results is different to the previous sub-sections. The characteristics of the incumbent workforce are not exogenous characteristics of the school, but reflect decisions made by the school given its circumstances. So the sorts of teachers that schools can hire are part of the mechanism through which the relationship between deprivation and turnover is mediated.

Looking directly at the tenure categories, there is still a quantitatively marginal association between neighbourhood IDACI score and short tenures in primary schools, and essentially no association in secondary schools. Similarly, there is a small association left between deprivation and longer tenures in secondary schools, and actually a perversely signed effect for the poorest primary schools. Because we are unable to link teachers to pupils we cannot look at turnover and teacher effectiveness as Boyd et al. (2008) do. The coefficients on deprivation for mean tenure remain significant once we control for teacher characteristics, though again they decline in size. In the primary school analysis, two of the coefficients change sign, reflecting also the change in the long-tenure category, though remain very modest in size.

As expected, most teacher characteristics are highly significant, and explain much of the tenure decision. Our results also support a U-shaped life-cycle pattern of turnover, with higher turnover for young and old teachers (the latter is likely to include retirements). Interestingly, we find that those teachers that teach shortage subjects (maths, physics, chemistry and foreign languages) have higher turnover rates. This result is supported in the literature (Grissmer and Kirby 1992; Podgursky, Monroe, and Watson 2004; and Smithers and Robinson 2004) and may be due to the fact that shortage subject teachers receive more job offers. We do not find consistent gender differences across all the specifications, as might have been expected given the simple unconditional means. Unlike Ingersoll (2001) and Boyd et al. (2011), we find that ethnic minority teachers have a higher turnover rate.

These results suggest that much of the correlation between neighbourhood deprivation and teacher turnover is mediated through teacher characteristics. In other words, deprived schools appear to hire younger and more ethnically diverse teachers than more affluent schools.

5.4. Discussion

The key results on novice and experienced teachers are as follows. Each value is the coefficient on the highest IDACI category relative to the mean value of the dependent variable for the lowest IDACI category:

	-------- Primary --------		------ Secondary ------	
TENURE	Novice	Experienced	Novice	Experienced
Base	16.38	−5.32	12.57	−26.70
+ pupil characteristics	12.87	(0.00)	12.57	−21.36
+ market characteristics	7.60	(3.72)	12.02	−17.48
+ teacher characteristics	4.68	5.85	4.37	−8.25

Derived from Tables 3 and 4. Values in parentheses are not significantly different from zero at 10%.

The secondary school results are generally consistent across the tenure categories shown. The size of the association is greater for the longer tenure lengths. Controlling for school, student and teacher labour market factors reduces the association between school poverty and turnover, but does not eliminate it. Adding teacher characteristics does. The results are slightly less clear cut and consistent in primary schools, but the same overall picture emerges. Once we control for basic teacher characteristics, there is little remaining relationship between disadvantage and turnover. This is

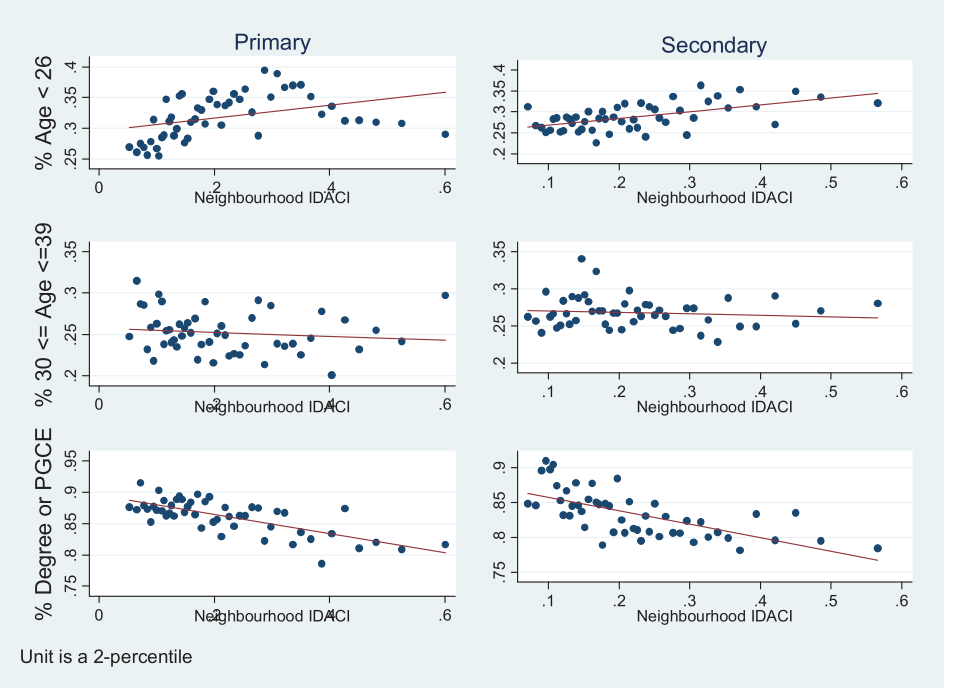

Figure 4. Teacher characteristics and school disadvantage.

because teachers hired by schools in poor communities tend to be younger and less well-qualified, as Figure 4 illustrates.

How should we interpret this? There are a number of possibilities. First, it could be that this is a desired career path for young teachers. New teachers may look for their first jobs near to where they trained, which implies predominantly urban and therefore on average deprived, schools. Alternatively it could be a desired career path deriving from younger teachers possibly having more idealistic preferences, and welcoming the opportunity to work in deprived schools. Under these interpretations, the market equilibrium allocation reflects the desire of younger teachers to work in deprived schools, and the higher turnover in such schools derives from this. The alternative interpretation is the matching story set above in which the more effective teachers sort on average into the more affluent schools, and the disproportionate number of inexperienced teachers in the poorer urban schools reflects the fact that these are the best teachers that those schools can hire.[17]

6. Conclusion

We study teacher turnover in England. We have shown that there is a positive raw association between the level of disadvantage in the neighbourhood that a school serves and the turnover rate of its teachers, although this is not large. For example, a secondary school in the most disadvantaged category has 2.3% points more teachers with short tenure than does a school located in the most affluent quartile, or 12.6% higher. This association diminishes as we control for school, pupil and local teacher labour market characteristics, but is not eliminated. The remaining association is largely accounted for by teacher characteristics, with the schools in poorer neighbourhoods hiring much younger teachers on average. We interpret this market equilibrium allocation as either deriving from the preferences of young teachers, or as reflecting the low market attractiveness of disadvantaged schools.

We finally consider what our results mean for school effectiveness, and evaluate the contribution of differential turnover to the lower performance of schools with disadvantaged students. A simple

framework is as follows. Consider a school with N teachers, who each teach S students. We abstract from growth or decline, the school remains the same size so always replaces teachers who leave. If the separation rate is λ per year, then there are λN novice teachers[18] and the remaining $(1 - \lambda)N$ are non-novice. The students taught by non-novice teachers each achieve a test score of g, but the students of novice teachers suffer an inexperience penalty of δ, so achieve $(1 - \delta).g$. The total test score in the school is $N(1 - \lambda).S.g + N\lambda.S.g(1 - \delta)$. The mean student score is $g.(1 - \delta)$. The higher is the separation rate or the inexperience penalty, the lower the mean test score.

Comparing two otherwise identical schools with high and low turnover, the gap in their test scores is equal to $-g\delta(\lambda^H - \lambda^L)$, or as a fraction of the low turnover school's mean score, $-\delta(\lambda^H - \lambda^L)/(1 - \lambda^L\ \delta)$. We can use the results obtained here plus an estimate of δ to put a rough empirical magnitude on this. The results show a conditional gap in short tenure teachers in secondary schools of 2% points. The mean short tenure fraction in the least poor schools is 0.18. We use an estimate[19] of δ from Slater, Davies, and Burgess (2012): 0.042. Plugging these into the formula yields a gap in mean student test score relative to the test score in the low turnover school of 0.00085. This channel contributes almost nothing to the test score gaps between disadvantaged and affluent schools. Of course, there are likely to be costs to student progress from the disruption to their studies from new teachers, but differential teacher turnover does not seem likely to be able to explain much of the test score gap.[20]

While the direct impact of turnover differences cannot explain socio-economic test score gaps, we know that differences in teacher effectiveness in general are very substantial (see Slater, Davies, and Burgess 2012). Analysis of the operation of the teacher labour market will give us a better understanding of how particular teachers are matched and re-matched with particular schools. The results in this paper provide a contribution to this research programme.

Notes

1. See for example Rockoff (2004), and Slater, Davies, and Burgess (2012) for England and Burgess (2016) for a summary.
2. See for example Dolton and Newson (2003) and Smithers and Robinson (2004)
3. Tenure here means time in a particular school, not time in the teaching profession as a whole.
4. We can only approximate total teaching experience as we do not know the date of the first teaching job.
5. These are statistics for full-time, secondary school, classroom teachers holding a degree.
6. We also know that inexperienced teachers are less effective for their first year or two.
7. See https://www.gov.uk/government/news/top-graduates-to-get-up-to-30k-to-train-to-teach-core-subjects (August 2017).
8. These can be seen in job adverts but as the adverts are temporary, they are not available on permanent links.
9. In a longer version of this paper, Allen, Burgess, and Mayo (2012), we use the cross-section to estimate separation rates. The results of that exercise are qualitatively the same as the analysis here.
10. The SWC guidance from the DfE defines support staff as "those … that are not classroom based, eg matrons/nurses/medical staff, librarians, IT technicians, technicians, administrative officers/secretaries, bursars and other administration/clerical staff, premises and catering staff"; and teaching assistants as "those … based in the classroom for learning and pupil support, eg HLTAs, teaching assistants, special needs support staff, nursery officers/assistants, minority ethnic pupils support staff and bilingual assistants."
11. We repeated all the analysis using a radius of 20 km, and the results are very similar: same pattern of coefficients and same levels of (in)significance.
12. For primary schools, we classify high market density as those schools which have more than 800 schools within 30 km, and low market density as those which have less than or equal to 200 schools within 30 km. Amongst secondary schools, high market density is classified as more than 200 schools within 30 km, and low market density as less than or equal to 50 schools within 30 km.
13. These are simple linear probability models for ease of interpretation, but nothing qualitatively changes when we use a probit model.
14. There are other school characteristics that we cannot measure: Ingersoll (2001) reports that a 1-unit difference between schools in support (on a 4-unit scale) is associated with a 23% difference in the odds of a teacher departing, while a 1-unit difference in reported teacher influence between schools (on a 6-unit scale) is associated with a 26% difference in the odds of a teacher departing.

15. Again, there are other variables that would be useful to have: Ingersoll (2001) reports that a 1-unit difference in reported student discipline problems between two schools (on a 4-unit scale) is associated with a 47% difference in the odds of a teacher departing.
16. See also Dolton and van der Klaauw (1999) and Ingersoll (2011).
17. If idealistic teachers are also ineffective teachers, then these two stories are not dis-similar, but we are unaware of any evidence available to date that can link teacher preferences and effectiveness.
18. Not all newly hired teachers will be teaching novices. About 40% of new hires in our data are of an age that makes them likely to be novices.
19. The novice penalty relative to the mean GCSE score.
20. This finding fits with others using other data. Ronfeldt et al. (2011) finds that within the same school and year, students in grade levels that experienced 100% turnover had 4%–7% of a standard deviation lower test scores in math and 3%–7% of a standard deviation lower in English Language Arts (ELA) as compared to grade levels with no turnover at all. Reducing teacher attrition rates from one-quarter of teachers leaving to none corresponds to an increase in student math achievement of about 2% of a standard deviation. Dolton and Newson (2003) find that increasing teacher turnover by 10% leads to SATS scores declining by 2% for English and 2.5% for Maths.

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References

Allen, R., S. Burgess, and J. Mayo. 2012. "The Teacher Labour Market, Teacher Turnover and Disadvantaged Schools: New Evidence for England." CMPO Working Paper 12/294. CMPO, Bristol.

Barmby, P. 2006. "Improving Teacher Recruitment and Retention: The Importance of Workload and Pupil Behaviour." *Educational Research* 48 (3): 247–265. doi:10.1080/00131880600732314

Bartholomew, D. J. 1982. *Stochastic Models for Social Processes*. 3rd ed. London: Wiley.

Boe, E., S. Bobbitt, and L. Cook. 1997. "Whither Didst Thou Go? Retention, Reassignment, Migration, and Attrition of Special and General Education Teachers from a National Perspective." *The Journal of Special Education* 30 (4): 371–389. doi:10.1177/002246699703000402

Boe, E., L. Cook, and R. Sunderland. 2008. "Teacher Turnover: Examining Exit Attrition, Teaching Area Transfer, and School Migration." *Exceptional Children* 75 (1): 7–31. doi:10.1177/001440290807500101

Boe, E., S. Shin, and L. Cook. 2007. "Does Teacher Preparation Matter for Beginning Teachers in Either Special Or General Education?" *The Journal of Special Education* 41 (3): 158–170. doi:10.1177/00224669070410030201

Boyd, D., P. Grossman, H. Lankford, S. Loeb, and J. Wyckoff. 2008. "Who Leaves? Teacher Attrition and Student Achievement." NBER working paper series no. w14022. National Bureau of Economic Research, Cambridge, MA.

Boyd, D., H. Lankford, S. Loeb, M. Ronfeldt, and J. Wyckoff. 2011. "The Role of Teacher Quality in Retention and Hiring: Using Applications-to-Transfer to Uncover Preferences of Teachers and Schools." *Journal of Policy Analysis and Management* 30 (1): 88–110. doi:10.1002/pam.20545

Burgess, S. 2016. *Human Capital and Education: The State of the Art in the Economics of Education*. IZA DP 9885. IZA.

Dent, A., and S. Bond. 2008. *An Investigation Into the Location and Commuting Patterns of Part-Time and Full-Time Workers in the United Kingdom, Using Information from the 2001 Census*. London: Office for National Statistics.

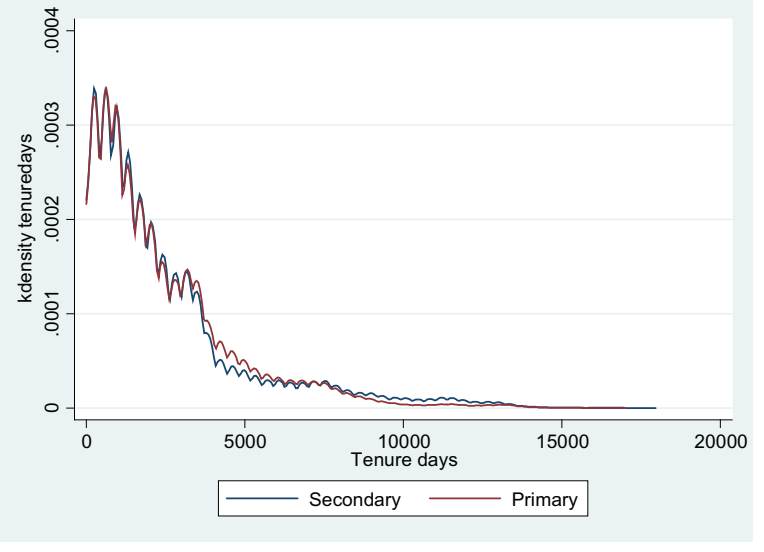
Dolton, P., and D. Newson. 2003. "The Relationship between Teacher Turnover and Pupil Performance." *London Review of Education* 1 (2): 132–140. doi:10.1080/14748460306685

Dolton, P., and W. van der Klaauw. 1999. "The Turnover of UK Teachers: A Competing Risks Explanation." *Review of Economics and Statistics* 81 (3): 543–550. doi:10.1162/003465399558292

Dolton, P., and W. van der Klauww. 1995. "Leaving Teaching in the UK: A Duration Analysis." *The Economic Journal* 105 (429): 431–444. doi:10.2307/2235502

Falch, T., and M. Ronning. 2007. "The Influence of Student Achievement on Teacher Turnover." *Education Economics* 15 (2): 177–202.
Grissmer, D., and S. Kirby. 1987. *Teacher Attrition: The Uphill Climb to Staff the Nation's Schools*. Santa Monica, CA: Rand Corporation.
Grissmer, D., and S. Kirby. 1992. *Patterns of Attrition among Indiana Teachers, 1965–1987*. Santa Monica, CA: Rand Corporation.
Hanushek, E., J. Kain, and S. Rivkin. 2004. "Why Public Schools Lose Teachers." *The Journal of Human Resources* 39 (2): 326–354. doi:10.2307/3559017
Harris, D., and S. Adams. 2007. "Understanding the Level and Causes of Teacher Turnover: A Comparison with Other Professions." *Economics of Education Review* 26 (3): 325–337. doi:10.1016/j.econedurev.2005.09.007
Hobbs, G., and A. Vignoles. 2007. *Is Free School Meals a Valid Proxy of Socio-Economic Disadvantage (in School Research)?* CEE Discussion Paper, Paper no: CEEDP0084.
Hutchings, M. 2011. "What Impact Does the Wider Economic Situation Have on Teachers" Career Decisions? A Literature Review (Research Report DFE-RR136)." Report commissioned by the Department for Education, London.
Ingersoll, R. 2001. "Teacher Turnover and Teacher Shortages: An Organizational Analysis." *American Educational Research Journal* 38 (3): 499–534. doi:10.3102/00028312038003499
Ingersoll, R. 2011. "Do We Produce Enough Mathematics and Science Teachers?" *Phi Delta Kappan* 92 (6): 37–41. doi:10.1177/003172171109200608
Krieg, J. 2006. "Teacher Quality and Attrition." *Economics of Education Review* 25 (1): 13–27. doi:10.1016/j.econedurev.2004.09.004
Lancaster, T. 1990. *The Econometric Analysis of Transition Data*. Cambridge: Cambridge University Press.
Lise, J., C. Meghir, and J.-M. Robin. 2013. "Matching, Sorting and Wages." LIEPP Working Paper March 2013, no. 11. Labour Market Research Group, Paris.
Loeb, S., D. Kalogrides, and T. Béteille. 2011. "Effective Schools: Demonstrating Recruitment, Assignment, Development, and Retention of Effective Teachers." NBER working paper series no. w17177. National Bureau of Economic Research, Cambridge, MA.
Podgursky, M., R. Monroe, and D. Watson. 2004. "The Academic Quality of Public School Teachers: An Analysis of Entry and Exit Behaviour." *Economics of Education Review* 23 (5): 507–518. doi:10.1016/j.econedurev.2004.01.005
Rockoff, J. 2004. "The Impact of Individual Teachers on Student Achievement: Evidence from Panel Data." *American Economic Review* 94 (2): 247–252. doi:10.1257/0002828041302244
Ronfeldt, M., H. Lankford, S. Loeb, and J. Wyckoff. 2011. "How Teacher Turnover Harms Student Achievement." NBER working paper series no. w17176. National Bureau of Economic Research, Cambridge, MA.
Shimer, R., and L. Smith. 2000. "Assortative Matching and Search." *Econometrica* 68: 343–369. doi:10.1111/1468-0262.00112
Slater, H., N. Davies, and S. Burgess. 2012. "Do Teachers Matter? Measuring the Variation in Teacher Effectiveness in England." *Oxford Bulletin of Economics and Statistics* 74 (5): 629–645. doi:10.1111/j.1468-0084.2011.00666.x
Smithers, A. and P. Robinson. 2003. *Teacher Turnover, Wastage and Movements between Schools. DfES Research Report 430*.
Smithers, A. and P. Robinson. 2004. *Teacher Turnover, Wastage and Movements between Schools. DfES Research Report 553*.
Stuit, D., and T. Smith. 2009. *Teacher Turnover in Charter Schools*. Nashville: National Center on School Choice, Vanderbilt University.
Tracey, L., M. Home, N. Mitchell, A. Hobson, A. Malderez, M. Biddulph, G. Pell, and P. Ashby. 2008. *Teachers' Experiences of Their Second Year in Post: Findings from Phase IV of the Becoming a Teacher Project*. Nottingham: Department for Children, Schools and Families.
Zabalza, A. 1978. "Internal Labour Mobility in the Teaching Profession." *The Economic Journal* 88 (350): 314–330. doi:10.2307/2232133

Appendix Figure



Appendix Figure 1: Kernel density function