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PAYING FOR PRIMARY SCHOOLS: ADMISSION CONSTRAINTS, SCHOOL POPULARITY OR CONGESTION?*

Stephen Gibbons and Stephen Machin

School quality is capitalised in house prices if access to schools is rationed by residential location. We generate empirical predictions from three different theoretical approaches linking house prices to school performance, distance to school and capacity. These are respectively based upon admission constraints, school popularity and congestion effects. We find that test-score-based school performance significantly increases property prices, but only the best one in ten schools generate higher than average prices close by, and that prices are higher close to popular, over-capacity schools. We conclude that the empirical evidence is more in line with the school popularity model.

Anyone with school age children worries about getting the best school for their child. Even so, the processes by which school choices are made, or indeed whether one gets an opportunity to choose, are complex. And yet, developing a better understanding of this choice process and its outcomes is fundamental to the distribution of educational attainments across children and the distribution of future income that this engenders. If indeed the rich get the best schools then this has clear implications for intergenerational mobility and equity.

As things stand in England, some opt for education outside the state sector – if they can afford it. Others must adopt a strategy to try to get their child into a decent state school. In the English primary school system, this generally means choosing a home near the school, because admission is restricted to those who live close by. So it is not surprising that evaluation of schools' relative merits and the choices to be made over where to live feature highly in parents' dialogue. But, as in any group discussion, talk might be based on limited (or maybe out-of-date) information which may shape the views of parents on schooling decisions for their children. This forms the backdrop for what we study in this article, namely the links between primary school performance, residential location, school capacity and house prices. We set up and test various models of school choice, implementing empirical tests using detailed house price and school data in London and the South East of England.

The primary school admission system is organised in England so that there is no deterministic relationship between location of residence and primary school attended. In fact, allocation purely on the basis of place of residence became illegal in the 1990s, after some well-publicised court cases. In principle, parental preference is what counts. In practice, good primary schools in urban areas are often full or over-subscribed, and geographically-based over-subscription criteria

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come into play. Living within some defined 'catchment area' can be important; but it is often just a case of nearest-in/first-in.

A standard approach to placing a monetary valuation on school quality is to trace out the effects of neighbourhood school quality on property values. But the 'nearest-in/first-in' feature of the admissions system in England generally rules out empirical strategies that exploit well-defined attendance district boundaries, as used in US work like Black (1999), or Bogart and Cromwell (2000). For primary schools, the only case where boundaries will be fairly non-porous is at the border between Local Education Authorities (LEAs).[1] These are the local government bodies (150 of them in England, around 20% of which are in London) that typically manage school funding and admissions. We used this particular boundary feature in Gibbons and Machin (2003) and exploit it again here. But we also need a more general approach for the majority of cases when LEA boundaries are not relevant.

The generally porous nature of school admissions geography implies that residence–school distance should have important impacts on the premium home-buyers pay for residences at locations close to good schools. This issue has received relatively little attention,[2] but is a central focus of this article. We are also interested in how competition and queues for places change the valuation of primary school performance. In the standard hedonic valuation of school quality researchers estimate a regression model in which the performance of a local school appears as an explanatory variable in the determination of house prices. We generalise this to allow for the fact that the extent to which a school is over-subscribed and the distance away that a child lives may have important implications for the probability of admission – and may influence valuations in other ways. Doing so permits us to test between different reasons as to why parents are willing to pay more for houses near better performing primary schools.

In our earlier work on schools and house prices in England (Gibbons and Machin, 2003) we used neighbourhood-aggregated housing and school data, with which we were unable to say anything about school distance. Our new study uses data with much more detail on house characteristics and geographical location, allowing us to measure house–school distance precisely and to implement more effective strategies for dealing with unobserved neighbourhood heterogeneity. Even so, it is encouraging to note that the baseline estimates on the school quality premium are similar in both our pieces of work.

The rest of the article is structured as follows. Section 1 is devoted to development of models showing how parental valuation can depend on school distance, and how admission constraints may impact on these relationships. We look at three models, respectively based upon admission constraints, school popularity

[1] This boundary feature is less applicable to secondary schools where pupils are more likely to cross LEA borders. From data on pupil addresses we know that under 6% of primary school pupils at age 11 live in LEAs outside the LEA of their school but these pupils are concentrated in a few schools (e.g. in Central London where there are few residents) and this includes many pupils who moved subsequent to admission. Otherwise, places are very mixed in terms of the school affiliation of resident pupils; for more detail see Gibbons *et al.* (2005).

[2] Though see Des Rosiers *et al.* (2001) and some of the results in Kane *et al.* (2003) for exceptions.

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and congestion effects, and generate empirical predictions from each. In Section 2 we describe the data and empirical methods we use. In Section 3 we present our estimates, and relate them back to the theoretical models presented earlier. Finally, Section 4 concludes.

1. Admission Constraints: Distance to School and School Capacity

The special features of the English schooling system described above mean that choosing a residence in a particular location does not guarantee admission to a primary school. This means that families choosing a home must make choices over at least three essential schooling-related factors. Our simplifying assumptions about residential choice are:

- A1 Families consider the average pupil performance in tests in the neighbouring school (s) relative to what can be expected in the general geographical search area.
- A2 Families consider the distance of the potential home to the school of interest (d), which influences expected school quality because it changes the probability of admission.
- A3 Families consider the capacity of the school (σ) relative to the number of pupils on the roll, which affects the probability of admission and is determined in part by a school's past popularity.
- A4 Admission considerations override transportation costs, because any location that is close enough to a school to permit admission has negligible costs of transportation.

Our claim in this article is that any residential location has an implicit school quality 'attached' to it, and that this implicit school quality varies in a continuous way over geographical space. (The only common break in this continuity is where there are discontinuities in admissions patterns caused by Local Education Authority boundaries, which we consider later). In this setting school admission constraints can act as an important feature in parental choice. Class size, infrastructure, resource and institutional constraints mean that school capacity is fixed in the short-medium run. However, the role of capacity relative to pupils in school choice is ambiguous, and we foresee three possible consequences:

- (*i*) A low capacity/pupil ratio implies *admission constraints* in that it limits the availability of school quality over distance, because there is an increased probability of exclusion at any distance due to more stringent proximity-based admissions criteria.
- (*ii*) A low capacity/pupil ratio signals *popularity*, which interacts positively with performance in terms of perceptions of school quality. Popularity could even mislead parents into believing a school is good when it is not (a possibility we return to later).
- (*iii*) A low capacity/pupil ratio suggests *congestion* with problems of physical overcrowding, and lack of flexibility. In this case we would expect under-capacity schools to be in higher demand.

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These conjectures give us several propositions about the role of s, d and σ in school choice. First, define an expected *school quality* function $q(s, d, \sigma)$ to represent the school quality available at a residential location at distance d from a school with performance s, with a capacity/pupil ratio of σ. School performance s is measured relative to local expectations ($s = s_i - \bar{s}$). Our propositions, which we will test in the empirical section below, are that:

- P1 Location-specific schooling quality $q(s, d, \sigma)$ is increasing in s, and the rate of change with respect to s is greater the closer you live to the school, because admission becomes more likely and you are more likely to enjoy benefits of better performance, i.e. $q_s(s, d, \sigma) > 0$, $q_{sd}(s, d, \sigma) < 0$.
- P2 $q(s, d, \sigma)$ is decreasing in distance if s is high, but decreasing in distance if s is low, because the further away you live from a bad school and the nearer you live to a good school, the higher the probability your children get to go to the good school and not the bad school. i.e. $q_d(s, d) < 0(>0)$ if $s > 0(<0)$.
- P3 If the admission-constraints conjecture is correct then school quality decays more rapidly with distance for over-capacity schools than under-capacity schools, i.e. $|q_{d\sigma}(s, d, \sigma)| < 0 \ \forall \ d$.
- P4 Also, if the admission-constraints conjecture is correct, σ should make no difference to perceptions of school quality at locations *very close* to schools, because no location offers a better chance of admission i.e. $q_{s\sigma}(s, d, \sigma | d = 0) = 0$. If this were not the case, rational home buyers would always choose properties close to those schools where the marginal cost of performance is lower.
- P5 If the popularity conjecture is right, then school performance has a bigger impact on perceptions of school quality when schools are over-crowded, regardless of distance. i.e. $q_{s\sigma}(s, d, \sigma) < 0 \ \forall \ d$. Importantly, $q_{s\sigma}(s, d, \sigma | d = 0) < 0$.
- P6 If the congestion conjecture is correct then school quality is increasing in the ratio of capacity, relative to pupils on the roll, $q_\sigma(s, d, \sigma) > 0 \ \forall \ d$.

These ideas are illustrated in Figure 1, in which we define $\sigma = 1$ for a typical under-capacity school, and $\sigma = 0$ for an over-capacity school. The upper Figure is the admission-constraint model, where perceived school quality declines with distance from better performing schools, and increases with distance from worse performing schools. In this model the existence of admissions constraints acts to restrict the availability of school quality such that perceived school quality erodes more rapidly with distance if the school is over-capacity than if under capacity (solid lines compared to dotted lines). The lower Figure shows the differing predictions of the popularity hypothesis. Here, as before, one obtains a steeper gradient between perceived quality and school test score performance for lower distance to school residences (solid lines compared to dotted lines). But now, admissions constraints act to increase the rate at which perceived quality increases with test score performance, so the gradients are steeper for capacity-constrained schools. In this congestion model, a low capacity/pupil ratio will shift the curves in Figure 1 downwards, relative to the curves for under-capacity schools.

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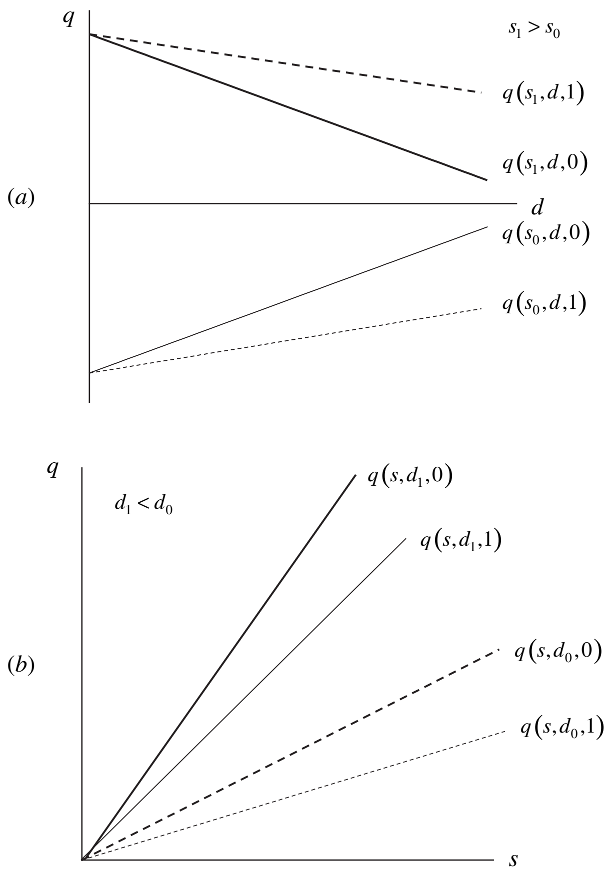

Fig. 1. *Conjectures About the Relationship Between Performance, Distance and Admissions Contraints.*

(*a*) *Admission constraints hypothesis: Admissions constraints limit the availability of school quality.* Perceived school quality q declines with residence–school distance (d) for good schools (s_1) and increases with distance from bad schools (s_0). With admissions constraints ($\sigma = 0$) the rate at which perceived quality decreases (or increases) with distance is higher than without ($\sigma = 1$). The probability of admission decreases more rapidly with distance than in under-capacity schools.

(b) Popularity hypothesis: Admissions constraints signal popularity and school quality. Perceived school quality q increases with test score performance (s). *The slope is higher for low residence–school distances* (d_1) relative to high distances (d_0). Admissions constraints ($\sigma = 0$) increase the rate at which perceived quality increases with test score performance.

The idea of the empirical section is to test Propositions 1–6 using an estimate of the location-specific school-quality function. This will allow us to distinguish between the alternative conjectures on the impact of capacity in school choice. To proceed, we assume that $q(s, d, \sigma)$ is the object of parental preference over schooling choices, which can be estimated by revealed preference methods in a hedonic property value framework; see Sheppard (1999) for a survey. Property prices trace out the function $q(s, d, \sigma)$, once other factors that affect housing demand are held constant. There is, of course, a large literature looking at

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willingness to pay for schools in a hedonic price setting but existing work uses a less general quality function $q(s)$. The distinguishing feature of our work here is to consider the more general quality function incorporating d *and* σ.[3] This, we believe, enables us to say a lot more about the source of house price premia associated with primary schooling. We will use the estimates of the partial derivatives and of s, d, σ in a property value regression model to estimate their derivatives in the school-quality function, and use this information to make our empirical judgements.

2. Methods and Data

2.1. *Data Sources*

Our data source for house prices and characteristics is the Nationwide Building Society's survey, based on all property sales in Great Britain for which the building society makes mortgage loans. We use the data from 1997 to the first quarter of 2002 and restrict attention to the Metropolitan area of Greater London and its surroundings. Schools data comes from the Department of Education and Skills' (DfES) Annual School Census from 1996–2001 and the publicly available school performance 'league tables'. Performance is measured in these tables as the proportion of children reaching target levels (Level 4) in the standard 'Key Stage 2' age-11 tests.

We match each property to its nearest three primary schools (and three secondary schools, and nearest private school) using Euclidian distances derived from address postcodes and their geographical coordinates using Ordnance Survey Codepoint™ data.[4] We also include some area characteristics, specifically dwelling density from the 2001 Census and some indicators of different concentrations and types of nearby social housing. We use two samples: a full sample for the London and surrounding area, and a sub-sample restricted to properties close to Local Education Authority boundaries in London (for reasons which will become clear in due course when we more fully discuss our modelling strategy). Sample characteristics are shown in Table 1.

Any residence may offer a number of alternative schools, so we need a way of linking schools to dwellings. We do this on the basis of how close each school is to each property. For each property in our data, we define a *local school cluster* as the set of three nearest primary schools. The *school performance* available to a particular dwelling i at time t is defined as the inverse-distance weighted average of the performance of these nearest three schools in all earlier years (because single year measures may be noisy indicators of long run performance). School-distance for a given dwelling is calculated as the harmonic mean of the nearest three school's distances. Thus a property adjacent to one school but further away from others, will be assigned the school performance of the adjacent school and a distance of

[3] As we have noted already, a few other studies consider the role of distance (Des Rosiers *et al.*, 2001; Kane *et al.*, 2003).

[4] A residential postcode is, typically, shared by 10–15 houses on one side of a residential street. 'Code Point' provides a National Grid reference for each unit postcode in Great Britain.

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Table 1
Key Summary Statistics

	Mean	Standard Deviation.
Full sample		
Log-property price	11.569	0.505
Primary school performance (annual)	0.679	0.140
Primary school performance (time average)	0.638	0.129
Primary school distance (100 m)	5.591	2.150
Admissions un-constrained schools (proportion)	0.585	0.493
Admissions unconstrained index	0.021	0.121
Sample size	106,717	
London LEA boundary sub-sample		
Log property price	11.688	0.515
Primary school performance (annual)	0.643	0.142
Primary school performance (time average)	0.601	0.127
Primary school distance (100 m)	5.014	2.117
Admissions un-constrained schools (proportion)	0.431	0.496
Admissions unconstrained index	−0.018	0.119
Sample size	21,065	

Notes. Properties with prices above £1 m are excluded from the Nationwide sample. Performance is the proportion reaching level 4 in Key Stage 2 tests at age 10/11. Full sample is for London and outer metropolitan area, restricted to properties with school-distance less than 1 km.

zero. A property that is equidistant from three schools is assigned the arithmetic-mean performance of the nearest three and the common distance. Any properties more than 1 km from a primary school are dropped, since we regard households living outside this as unconcerned with primary school performance issues.

To test our propositions on school capacity (P3–P6 above) we need an index of capacity relative to pupils. We utilise a physical school capacity measure based on the number of classroom spaces. In primary schools, this was an important factor in constructing the 'standard number' used by LEAs to determine the number of admissions for each school. Our assumption is that ratio of physical capacity to pupils in any year is a reasonable measure of the extent to which schools are likely to be admissions-constrained in the following year. To be precise, the variable σ in the local school quality function $q(s, d, \sigma)$ is defined as $\{1 -$ (full time equivalent pupils)/(school capacity)$\}$ (where the ratio of pupils to capacity at any location is an inverse-distance weighted average of this ratio in the nearest three schools).

2.2. *Empirical Model*

Putting together the theoretical reasoning of Section 1 with the information described above leads us to the following empirical specification:

$$\ln p_{it} = q(s_{it-1}, d_i, \sigma_{it-1}; \gamma) + \mathbf{x}'_{it}\boldsymbol{\beta} + f_s + \varepsilon_{it} \quad (1)$$

where p_{it} is the price of property in postcode unit i at time t, q is postcode-unit-specific expected school quality which is a function of: s_{it-1}, the postcode-unit-specific measure of performance in the local school cluster in the previous period;

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d_i, the postcode-unit-specific school-distance defined above; and σ_{it-1}, the index of school capacity, relative to pupils (in the standard approach in the literature q is only a function of s). In (1) $\mathbf{x}_{it}$ is a vector of other observable characteristics, ε_{it} is the usual random error term and we allow for unobserved spatial fixed effects, f_s, related to the school cluster s.

2.3. *Area Effects on School Performance*

Any study of the effects of schools on house prices must take account of general neighbourhood factors. Anything desirable about the neighbourhood – local amenities, community attributes, or housing quality – will drive up local prices. In a world of imperfect capital markets, the rich outbid the poor for desirable neighbourhoods, e.g. Benabou (1996); Epple and Romano (2000). If children from richer backgrounds do better at school, then observed school quality is better in richer neighbourhoods. School performance and house prices are simultaneously determined, and regression estimates that do not take this sorting into account are biased. Work on school price effects has tried to get round this via a number of identification strategies. These include: specifying an extensive range of neighbourhood attributes in the property value regression (Downes and Zabel, 2002); looking at differences between neighbouring properties in different school attendance districts (Black, 1999; Gibbons and Machin, 2003); exploring what happens when school district boundaries are redrawn (Bogart and Cromwell, 2000); using spatial econometric techniques (Brasington and Haurin, 2005) or semi-parametric methods to eliminate general spatial variation (Gibbons and Machin, 2003).

Here we use a combination of approaches but our main device is to specify *school-cluster* fixed effects in our regressions. Persistent effects common to all properties in the school cluster can be accounted for in our property price regressions by a standard fixed-effects strategy, using observations in the same 3-school cluster to calculate the fixed effects. In our setup, an observation is assigned to a school cluster with other observations that share the same nearest, second nearest and third nearest primary school. Observations in the same group can be property transactions from the same postcode in different periods, or from different postcodes in the same or other periods.

The point of this strategy is to remove as much cross-sectional variation as possible,[5] whilst retaining the scope for measuring residence–school distance effects. Indeed much of the identification in our model comes from differences in the time trends of school-cluster performance. But not all: some cross-sectional variation remains between properties within 3-school clusters. This is because each residence has a unique residence–school distance vector, and so offers a unique quantity of school-quality within the cluster.[6] Residence–school distance effects are

[5] An alternative approach would be to use repeated observations of sales in the same postcode unit. This would result in a serious loss of data and information, since the sample of repeated postcodes is quite small, and would make it impossible for us to measure distance effects.

[6] In practice we can eliminate this variation in performance, with little effect on the performance results, by using simple means rather than spatially weighted means.

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identified here because each 3-school cluster has a different mix of properties in each year, so the mean residence–school distance is not constant over time.

Our second approach for eliminating area effects is to transform (1) into a spatially differenced model that eliminates area fixed effects. For any characteristic x_i associated with dwelling i, we calculate the characteristic x_j of a geographically 'neighbouring' dwelling j, and work with the spatially differenced variable $x_i - x_j$ in our regressions. This eliminates any neighbourhood effects that are common to both dwellings. But the transformation will also eliminate any differences in school performance unless we make efforts to ensure that our neighbouring dwellings have access to different schools. Our efforts exploit the discontinuities in admissions that occur at Local Education Authority boundaries, in a similar way to Black's (1999) use of admissions districts in Boston, that is we use differences between matched pairs of dwellings that are 'neighbouring', but in different LEAs. Each dwelling is matched to its nearest neighbour in an adjacent LEA in any year and we restrict the sample to ensure that all neighbours are within some specified distance of each other.

3. Results

3.1. *Performance, Distance, and Prices*

Our empirical results are derived from statistical regression estimates of the house price model in equation (1) under alternative specifications. We parameterise q as a simple linear function of s, d, and σ with interaction terms, and we make strong efforts to deal with the potential endogeneity of school performance using the strategies laid out in Section 2.3. The results relating to our hypotheses about distance and admissions constraints are in Tables 2 and 3.

We look first at distance and performance effects only in Table 2, where the school quality function $q(s, d, \sigma)$ is parameterised as a linear function of distance, performance and a distance-performance interaction (at this juncture we do not consider capacity σ). The basic effect of school performance is in Row 1. This should be interpreted as the effect of school performance on a property at the school gate (zero distance). Column (a) is a property value model with a full set of property controls, area characteristics, time effects, and Local Education Authority dummy variables. In this specification the impact on house prices is large – up to 5.4% for a 10 percentage point shift in school performance.[7] This is close to the largest results we reported for English primary schools in Gibbons and Machin (2003) and is similar to Black's (1999) analysis of US elementary schools. However, controlling for unobserved neighbourhood factors through school-cluster fixed effects in Column (b) almost halves the effect. Now, the main effect of performance is 3.0% on prices for each 10 percentage-point improvement in the proportion of children reaching the target test grade. This is almost exactly in line with our previous results for the South East of England, using a different source of aggregated house price data and a very different cross-sectional specification.[8] *The*

[7] Calculated as [exp $(0.528 \times 0.1) - 1] \times 100$.

[8] From Gibbons and Machin (2003) the estimate is 2.9% for a 10 percentage point improvement.

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Table 2

Performance and Distance Interactions

	OLS (a)	Within cluster (b)	IV- Within cluster (c)	X-boundary (d)
School performance	52.816**	29.139**	37.969**	27.370**
	(15.04)	(14.06)	(4.92)	(8.62)
Distance (100 m)	0.493	1.943**	2.759**	1.216**
	(1.36)	(10.15)	(4.06)	(4.91)
Distance × performance	0.202	−2.449**	−3.679**	−1.772**
	(0.38)	(−8.63)	(−3.59)	(−4.56)
Area effects	52 LEA	14297 school	14297 school	London LEA borders
Sample size	106,717	106,717	106,717	21,065
R^2	0.822	0.836	0.835	0.732

Notes. Dependent variable is log property price.
Sample restricted to properties with less than 1 km school distance.
Coefficients are ×100.
** Indicates significant at <1% level.
t statistics in parentheses
Performance and capacity measures in year t are derived from school-specific means of years 1 to $t-1$.
Instruments for performance are beacon school status, church school status, age-range (nursery, junior only) and their interactions with school-distance.
Mean inter-property distance in (d) is 500 metres, maximum 1 km.
Regressions include a full set of property controls, area characteristics, time effects.

Table 3

Performance, Distance and Capacity Interactions

	Within cluster (a)	X-boundary (b)	Within cluster (c)	X-boundary (d)
School performance	29.138**	26.700**	30.041**	25.858**
	(14.05)	(8.31)	(14.20)	(8.27)
Distance (100 m)	1.943**	1.216**	1.885**	1.175**
	(10.15)	(4.91)	(9.45)	(4.70)
Distance × performance	−2.449**	−1.761**	−2.408**	−1.701**
	(−8.63)	(−4.53)	(−8.16)	(−4.36)
Under capacity index	−0.007	−2.142	12.006	−1.764
	(−0.01)	(−1.38)	(1.56)	(−1.02)
School performance × under-capacity index	–	–	−25.416*	−35.703**
			(−2.22)	(−3.13)
Distance × under-capacity index	–	–	−0.540	−0.058
			(−0.40)	(−0.21)
Distance × performance, × under-capacity index	–	–	0.647	0.164
			(0.32)	(−0.08)
Area effects	14297 school	London LEA borders	14297 school	London LEA borders
Sample size	106,717	21,065	106,717	21,065
R^2	0.836	0.732	0.836	0.732

Notes. Dependent variable is log property price.
Sample restricted to properties with less than 1 km school distance.
Coefficients are ×100.
t statistics in parentheses
** Indicates significant at <1% level, * at 5% level.
Performance and capacity measures in year t are derived from school-specific means of years 1 to $t-1$.
Mean inter-property distance in (b) and (d) is 500 metres, maximum 1 km.
Regressions include a full set of property controls, area characteristics, time effects.

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positive and significant coefficient on performance (s) *is supportive of the claim in Proposition P1* (though these results are unconditional on school-capacity).

The fixed effect estimate of Column (b) must be a more robust estimate of the parameters and we disregard the OLS results from now on. Consider the effect of school distance and its interaction with performance in the school-cluster fixed effect model. The main effect of distance from low-performing schools (Row 2) is positive: prices rise by about 1.9% per 100 m distance from a school with an implied zero performance score. However, the significant distance-performance interaction term in Row 3 implies that this negative school impact is ameliorated by school performance: for schools with 79%[9] and more of their pupils attaining the target grade. This represents the 90th percentile in the long-run performance distribution. Above this, the distance effect switches sign. This shows that people pay to move very close to schools at the top of the attainment distribution. The interaction term also means that distance from a school reduces the school performance premium. Thus the performance of nearest schools matters less for prices of properties that are furthest away, each 100 metres reducing the house price performance premium by around 8.4% of its initial value.[10] *These findings are supportive of Proposition P2.*

Columns (c) and (d) investigate the robustness of these results using alternative identification strategies. Column (c) instruments school performance with salient school characteristics[11] resulting in slightly bigger coefficients on performance, but the general pattern of interactions is unchanged. Column (d) uses the cross-LEA border differences to identify the effects of access to different schools in a similar way to Black (1999), Bogart and Cromwell (1997, 2000) and Gibbons and Machin (2003), as described in the modelling sections above. The sample in Column (d) is much smaller and less representative than the sample used in Columns (a)–(c) because we restrict it to properties that are within 1 km of the nearest on the other side of a LEA boundary. Consequently, we might expect some differences in the estimates. Nevertheless, the patterns in Column (d) are broadly similar to those derived from the school-cluster fixed effects in Column (b), though the distance effects are less marked.

3.2. *. . .with Admissions Constraints*

In Table 3 we incorporate admissions constraints into the statistical within-cluster and cross-border models (viable instruments are not available for the fully interacted models, so we proceed no further with IV estimation). First, in Column (a) and (b), we include our index indicating the degree to which schools are under-capacity. In (c) and (d) we interact this with the distance and performance vari-

[9] The marginal effect of distance is 0.0194–0.0245 $\times$ s. Setting to zero and solving for s gives this result.

[10] Because each 100 m step reduces the premium by 0.0245/0.2914 = 8.4% relative to the zero-distance premium.

[11] As instruments we use indicators of the institutional age range (with nursery, junior years only), church-school status and 'beacon' school status, all interacted with distance. A 'beacon' school is a school designated by the Department of Education and Skills as exhibiting high teaching standards and models of good practice.

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ables. To interpret the coefficients, note that the definition of the capacity index means that the main effects of performance, distance and their interactions in Rows 1–3 relate to schools that are just at full capacity (pupils/capacity = 1, so our index of under capacity = 0).

In Columns (a) and (b) the estimated coefficient on the under-capacity variable is negative, but small and never statistically significant. This shows no direct effect, on average, from admissions constraints on house prices. On this basis Proposition P6, which predicts lower house prices near over-crowded schools due to a *congestion* story, seems incorrect, though we still need to include the full interactions between capacity, school performance and distance. These are in Columns (c) and (d) which show significant interactions between admissions constraints and the effects of performance and distance.

The full implications of these models are explored in an earlier draft of this article (Gibbons and Machin 2004), but here we focus on the key features as they relate to Propositions P1–P6. First note that the main effects of performance (Row 1) are still positive and significant and the interactions between performance and distance are negative (Row 3), in line with Propositions 1 and 2. As a consequence, the *very best* schools pull up prices of dwellings within their immediate vicinity relative to those further away. Households pay lower prices for properties close to primary schools, *unless* schools succeed in getting over 80% of their pupils up to the target grades (the top 10% in the long-run performance distribution).

Focussing now on the role of admissions constraints, the first thing to note is that the main effect of under-capacity is insignificant, and either large and positive, or small and negative, which seems to rule out our congestion conjecture. The next important thing to note is the weakness of the interactions between capacity and distance, or between capacity, distance and performance, in Rows 6 and 7 of Table 3. This means that admissions-constraints have little or no influence on the way that the price of a dwelling changes with distance from neighbouring schools. *Proposition 3 appears to be incorrect.* Note too that the interaction between school performance and under-capacity is negative and significant (Row 5), implying that capacity-constraints change the implicit price of performance at *any* distance. So, over-capacity schools are valued more, even at locations 'at the school gate' when admission must be virtually guaranteed. *This contradicts Proposition P4, in favour of Proposition P5.* The implications of these findings are that our admission-constraints conjecture appears inconsistent with the empirical findings, and the popularity conjecture more plausible.

In fact, the premium for a 10 percentage-point improvement in school quality at zero distance from over-capacity schools is 26% higher than that for under-capacity schools: 3.4% as against 2.7%.[12] This has quite substantial financial implications. At current prices, parents can expect a move from an average dwelling outside a weak school, to one outside a top over-subscribed school, to cost around £61,000 (26% of the mean property price in London and the South East in April–June

[12] Using the column (c) results, and calculated as $\exp(0.10 \times 0.300 + 0.10 \times 0.12 \times 0.254) - 1 = 0.034$ and $\exp[0.1 \times (0.300 - 0.10 \times 0.12 \times 0.254)] - 1 = 0.027$ from Row 1 and Row 5, where 0.12 is a 1 s.d. shift in the over-capacity index.

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2004). A similar move to an undersubscribed top school would cost, on average, about £49,000 – some £12,000 less!

3.3. *Interpretation and Discussion*

The reported results reveal a number of features of the house price-school performance relation. First, in line with other studies such as Black (1999) and Gibbons and Machin (2003) for primary schools, and Leech and Campos (2003) and Rosenthal (2003) for secondary schools, Cheshire and Sheppard (2004) for both, higher test-score-based school performance is associated with increased property prices. However, we find it is only the best one-in-ten schools that generate higher than average prices close-by. Second, there are important interactions between performance and residence-school distance and school capacity that induce systematic variations in the house price premium associated with better neighbourhood primary schools. Third, the nature of these interactions allows us to discriminate between different theoretical reasons as to why parents are prepared to pay higher prices for living in an area that will enable to get their children admitted to a particular school.

So how are we to interpret the results in the light of our earlier theoretical discussion? First, there is little evidence for a *congestion* model in which demand for over-capacity schools is low. This implies rising local house prices in neighbourhoods where schools are becoming less crowded, which is not what we observe. Secondly, admissions-constraints have almost *no* impact on the rate at which prices change with school distance and the performance premium is higher for admissions-constrained schools even at zero distance to the school. Thus, the results are supportive of our *popularity* conjecture, with complementarities between the signal provided by schools being full and the measured performance of the school. On the contrary, we find no evidence that our *admission-constraint* hypothesis is correct: there is no premium to be paid for moving closer to an admissions-constrained school.

Our claim then is that admissions constraints influence the process of school and residential choice, not by forcing parents to move much closer to full schools to increase the chances of admission, but by signalling popularity and encouraging demand. An alternative interpretation is that over-capacity, admissions-constrained schools are simply better quality schools in a way that is observable to parents but unobserved to us. Under this scenario, admissions constraints do not influence school choice decisions. Instead, better schools – that is better in ways that are not represented fully by our test score performance measure – push up property prices and become over-capacity through popularity. This would change the interpretation of our results only slightly. The interaction between performance ratings and under-capacity would, under this scenario, still show that popular schools that are good league-table performers attract higher prices than less-popular schools of a similar standard. But the popularity is attributable to desirable school attributes that are complementary to test-score performance.

Whilst this is a plausible position, further analysis makes it seem untenable. We re-estimated the models of Table 3 Column (c) with additional controls for a

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number of possible performance-complementary school attributes including the actual pupil average point-scores on the age-10/11 tests (rather than the proportion reaching the target level), the point scores in age-6/7 tests, educational 'value-added' that parents could expect the primary schools in the sample to impart to their children, plus indicators of other salient school characteristics like age structure, designation by the Department of Education and Skills as a high-standard 'beacon' school, and the number of qualified teachers. None of this makes much difference to the general pattern of results and the performance-capacity interaction remains stable and statistically significant. If the performance-capacity interaction in the house price models indicates some unobserved performance-complementary school attribute, then it is not a school-quality attribute that is easily recognised from the list of usual suspects. It seems that school performance has more of an impact on house prices when schools are over-capacity, simply because the over-capacity, admissions-constrained schools attract more attention. In principle, the popularity of a school provides information to prospective home buyers on the quality of schooling they can expect, though for the areas and schools we study, this information does not seem to have much substantive content.

4. Conclusions

This article presents new estimates on the value of primary schooling for London and its wider metropolitan surroundings. We develop methodologies that are appropriate for the English setting where admission catchment areas are fuzzy and porous, and which take account of unobserved neighbourhood effects. Our results are based on changes in performance of schools over time and on highly localised variation in school performance within micro-geographic neighbourhoods. Our baseline results indicate a premium of around 3.0% on prices for each 10 percentage point increase in children reaching target grades in age-11 tests. This premium relates to a property notionally located outside the school gate.

Our first improvement on previous work is to present plausible estimates of the effects of school distance on the performance premium. Each 100 m distance to a school erodes the performance premium by about 8.4% relative to its initial level, so by 600 m the premium is halved. We have also shown that all but the top 1-in-10 schools – judged on their long-run league-table performance – depress prices in their immediate vicinity. Average schools are not desirable local amenities. This may, in part, be explained by 'flight' from the worst schools, but environmental problems also probably contribute. The morning and evening 'school-run' brings traffic and congestion, and additional nuisances such as playground noise may deter buyers; for more on environmental effects and their negative impacts on prices see Hendon (1973).

Admissions constraints do seem to have important effects on parental decisions over schooling, in that there are significant interactions between measures of school over-capacity and the premium paid for high performing schools. Our first *admission-constraint* conjecture was that households will pay more to live ever closer to high-performing, over-capacity schools than under-capacity schools because

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school places are tightly rationed. This is not borne out by our data. Nor is the notion that *congestion* effects make over-subscribed schools less attractive to parents. A school that is admissions constrained is worth more than one that is not throughout most of the performance range and this impact is not sensitive to distance.

Instead, the empirical results are consistent with our *popularity* conjecture in which parents believe, rightly or wrongly, that popular schools are better than under-capacity schools. This popularity effect might indicate unobserved desirable school attributes that are complementary to league-table performance, yet we find it difficult to uncover any evidence of this. Thus there is a possibility of some degree of 'herd' behaviour in primary school choice, with the price not perfectly reflecting the fundamentals. Parents certainly do pay to get their children into better performing primary schools but it is evident that they prefer popular, over-subscribed schools. This seems to be the case even if their league-table results may not be up-to-scratch at the time admissions applications are made by parents.

Our results then convey a mixed message in terms of the role of residential sorting on educational inequality. On the one hand, the best schools carry a heavy price premium so school neighbourhoods are stratified by income with the poorest pupils excluded from the top-performing schools. There is indeed 'back-door' selection by income into primary schools.[13] On the other hand, rich families may wastefully pay for the popularity signal of over-capacity schools, when the substantive content of this signal is weak. Or they may be paying purely for consumption benefits of certain types of school – safety, physical attributes, or ethos – which could mean that the poor are excluded from the 'nicest' schools, but with little real impact on their life chances.

London School of Economics
University College London

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[13] The English press has coined the term 'selection by mortgage' to describe this phenomenon.

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