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The capitalisation of school choice into property prices: a case study of grammar and all ability state schools in Buckinghamshire, UK

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Abstract

There has been a growing academic and policy debate in the UK on the relationship between school choice, educational performance and house prices. School choice and the chances of attending a good school are important as it relates strongly to educational attainment and qualifications, University entry and access to the labour market. This debate was reinvigorated recently when the Conservative Party announced that state schools which select using academic ability (grammar schools) may be able to expand in England for the first time in decades. Some commentators argued that this may exacerbate and re-enforce existing inequalities in the education system by allowing wealthy parents to 'buy' into a particular grammar school via the housing market, leading to "selection by mortgage" as well as by academic ability. This research investigates the extent to which state schools are capitalised into house prices using Buckinghamshire in England as a case study. It differentiates between grammar schools and all ability state schools, using a novel multi-level specification of the repeat sales model. It concludes that single sex boys' grammar schools attract a higher premium than single sex girls' grammar schools and that in general, grammar schools attract a higher premium than all ability state schools. These premiums are a function of educational attainment and demand for places and tend to vanish once these have been taken into account, although for a small number of schools notable

premiums remain, perhaps reflecting school characteristics such as reputation not captured in the models.

Keywords

School choice; educational attainment; grammar schools; house prices; repeat sale; catchment areas

Highlights

- Buyers pay more for houses in over-subscribed boys' grammar schools catchment areas
- Houses in multiple catchments command higher premiums suggesting risk spreading
- Buyers pay more in all ability catchments where pupils are more likely admitted
- Prices of family sized homes have the largest premiums in relation to school choice

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1. Introduction

Over the past two decades there has been a growing academic and policy debate in the UK on the relationship between school choice, educational performance and house prices (Cheshire and Sheppard, 2004; Glen and Nellis, 2010; Gibbons and Machin, 2003; 2006; Leech and Campos, 2003; Rosenthal, 2003). School choice and the chances of attending a good school are important as it relates strongly to educational attainment and qualifications, University entry and access to the labour market and therefore social mobility in later life (Burgess and Briggs, 2010; Hamnett &Butler, 2011). In this respect, Waters (2016) uses Bourdieu's concept of cultural capital to describe how people's life chances can be directly influenced by the social assets they accrue, with the accumulation of academic credentials being central to this process. She argues that cultural capital in the form of educational qualifications is becoming an increasingly important determinant in accessing professional occupations and that this is particularly affecting middle class families who depend upon such occupations as a means of reproducing their social status. Increased competition in both the education sector (where more than 40% of young people in the UK now go to University) and the labour market (where once non-graduate jobs now require a degree) are driving

(middle class) families to increasingly strategise around their children's education so as to maintain access to the best qualifications and therefore jobs. This often means getting their children into state schools which have the reputation for both excellent examination results and for the progression of their pupils into the top Universities upon leaving school. As will be discussed, these strategies form part of a wider discourse on school choice, educational attainment and the role that local housing markets play in structuring access to the best state schools in an area.

Recently, these debates were reinvigorated when the Prime Minister, Theresa May, proposed the expansion in England of state schools that select by academic ability via competitive examination (known as grammar schools) as a key part of the Conservative government's education policy, overturning the 1998 School Standards and Framework Act which prohibited the establishment of new selective state schools. This manifesto promise was subsequently dropped after the General Election in June 2017 but not before commentators had argued against the proposed expansion of grammar schools on the grounds that it would exacerbate and re-enforced existing inequalities in the education system. In brief, the argument went that a particular strategy for wealthy parents was to 'buy' into a particular grammar school partly

through purchasing extra resources to help their children pass the entrance exam but also by buying or renting a home close to the grammar school as a way of increasing the chance of their children being admitted if they passed the exam. Since an over-subscribed (grammar) school will often use catchment area and distance to home address as criteria in their admissions policy (Hamnett & Bulter, 2011) this could lead to "selection by mortgage" (Leech and Campos, 2003; Gibbons and Machin, 2006; Harris et al.2016) as well as by academic ability. Consequently, school quality in general, and the means to access popular schools such as a local grammar school in particular, will be capitalised into house prices and school choice will be partly a reflection of parents' ability to pay for housing. This situation is not unique to the UK and mirrors long-running debates in other countries (see Nguyen-Hoang and Yinger, (2011) for a recent review), notably in the US (e.g. Bogart and Cromwell, 2000; La, 2015), but also in places such as Australia (eg Davidoff & Leigh, 2008) and Singapore (Agarwal, et a;. 2016).

This research is therefore concerned with the extent school quality is capitalised into house prices in England, an area that remains relatively under-researched despite the political and policy discourses around the subject. It uses the county of

Buckinghamshire, north-west of London, as a case study as the county is only one of ten authorities in England where an academically selective system of education fully remains and so has both grammar and all ability state schools which have overlapping catchment areas covering the entire county. It will investigate three main questions: i. whether grammar schools command a higher house price premium than all ability state schools once academic performance is taken into account; ii. whether over-subscribed schools command a higher premium than schools which have spare capacity and thus the effect on prices by demand for places; and iii. whether houses in multiple catchment areas attract a higher premium than those in single catchment areas, effectively measuring whether house buyers are paying more to spread the risk by increasing the likelihood of their children getting into a good school. It will also investigate whether house price premiums vary by house type, reflecting the demand for family houses. The rationale behind these three questions is discussed in the next section. The research uses a natural experiment approach and a novel multi-level repeat sales methodology to measure the effects of changes in school quality to changes in house prices over time for the different types of school. The paper is divided into five sections. Section two provides the background to school choice and admissions in England, and the economic framework underpinning the research. Section three discusses the data and methods in light of recent research in this area.

Section four provides the analysis and the final section provides a discussion and conclusion.

2. School choice and house market dynamics

2.1 Brief summary of school choice in England

Since the 1988 Education Reform Act, successive Labour and Conservative Governments have stressed the importance of school choice for parents and have implemented policies that allow parents to select the schools they want their child to attend. They have published school attainment tables and Office for Standards in Education, Children's Services and Skills (OFSTED) inspection reports to help parents in making these choices. This has created a quasi-market approach to allocating pupils to schools (Brighouse, 2002; Harris and Johnston, 2011; Singleton et al., 2011). Inevitably, differences in school quality in terms of educational outcomes can lead to increase demand for some schools over others and the emergence of a hierarchy of school desirability where parents compete to get their children into a good school (Hamnett

and Butler, 2011; Allen et al., 2012). Where many parents have selected a school as their first preference and it is oversubscribed, the admissions authority will apply oversubscription criteria to select which children will attend. These admissions policies are published so parents know how to maximise the likelihood that their child will be selected.

Schools admissions policies often use two distinct geographical criteria in allocating pupils to available places: catchment areas and distance (Hamnett and Butler, 2011). Catchment areas are often viewed as *de jure* although children living within the boundaries are not guaranteed a place whist those outside are not exclude; success depends upon the availability of places (Singleton et al., 2011; Harris & Johnston, 2011). If a school is over-subscribed and there are first preference pupils in the catchment area that remain unallocated, distance from home to school is often then used as a deciding criterion. This can lead to smaller *de facto* catchment areas based on proximity contained within the boundaries of the official catchment areas (although with less popular schools, these can extend beyond the official boundaries). Unlike the official catchment areas, these *de facto* proximate catchment areas can change annually depending on the vagaries of the allocation process so a pupil accepted based

on the distance criterion one year may not have been accepted the following year. As a result of this process, Harris and Johnston (2011) state that the vast majority of pupils (80–90%) are in the school given as their first preference on their application form (p. 493). However, Burgess & Briggs (2010) show that that around 54% of children (59% in rural areas) do not attend their nearest school, and 28% do not attend one of their nearest three schools.

Therefore, most school admissions policies typically operate a geographical form of rationing and restricting access to popular schools. This in turn can lead to rent-seeking behaviour in parents, with those with a greater degree of residential choice attempting to locate closer to a good school (Glen and Nellis, 2010; Agarwal., et al. 2016). Under the conditions outlined below, this rent seeking behaviour can be capitalised into property prices**.** This can then lead to a cycle of residential sorting of local neighbourhoods reinforcing social class differences with house prices becoming significantly higher in the areas of the most popular schools (Hamnett and Butler, 2011). In terms of cultural capital, the early work by Ball et al. (1995) on educational choice within London reveals that class position is the central and deciding factor when it comes to understanding mobility at secondary-school level. Burgess and Briggs

(2010) show that in England, a child from a poor family is half as likely to attend a good secondary school as a non-poor child and that this has to do with where they live. They conclude that location is the most important factor lying behind whether a child attends a good school and that this is a reflection of house prices, supporting the earlier findings by Cheshire and Sheppard (2004).

2.2 Supply, demand and the housing market

Cheshire and Sheppard (2004) identify three factors determining the extent to which school quality and school choice becomes capitalised into house prices. First is the elasticity and nature of housing supply. The supply of housing is traditionally considered as being inelastic in the short to medium term with a fixed stock that is difficult to adapt to demand. In the UK this has been exacerbated by a lack of supply of new housing. The availability of substitutes in the stock for families with children is also a factor which can influence demand; for instance, if there is a lack of family housing in neighbourhoods with popular schools. Houses with more bedrooms are more likely to be home for families with multiple children and so the school quality premium may be larger (Davidoff & Leigh, 2008; La, 2015; Cheshire and Sheppard,

2004). Second is the availability of substitutes in the supply of education. If an area has a large number of schools providing good and comparable quality education, then there may be little effect on house prices with any effect becoming smaller as average level of school performance increases. It is when school quality is constrained that it is more likely to become capitalised into house prices, with schools perceived to be good experiencing an increase in demand for places. As the supply of school places is inelastic to demand in the short term this can lead to oversubscription and therefore competition between parents. School capacity is also fixed in the short to medium term (Gibbons and Machin, 2006) as it may not be in the interest of a popular school to expand beyond a certain size due the diseconomies of scale associated with educational quality (e.g. larger class sizes). So a popular school may experience oversubscription and competition for places for many years. The publication of school league tables and other school data is also likely to exacerbate the popularity of the best performing schools. Third is the anticipation by parents of changes in the quality of education provided by schools. This may change over time and basing future school quality on current school provision is subject to a degree of risk, especially if a pupil is going to attend the school for several years. School admissions policies may also change over time with the redrawing of catchment area boundaries potentially having a critical impact on the probability of a child attending a school in the future.

Redrawing of boundaries are more like to take place in areas of population change and new build where the demographics of school age children are in flux (Cheshire and Sheppard, 2004).

2.3 **UK Case Studies**

The link between house prices, school choice and educational attainment is widely recognised in the US, but this association it is not as tight in the UK (Gibbons and Machin, 2003) and there has been relatively fewer studies (e.g. Glen and Nellis, 2010). In a review of the international literature, Nguyen-Hoang and Yinger (2011) found that almost all studies revealed a positive relationship between house price and school quality as measured by student test scores. In England, Rosenthal (2003) estimated an elasticity of house price with respect to secondary school test score (GCSE) of around 0.05 percent, although this was for the country as a whole. In contrast, Glen and Nellis (2010) calculated price elasticities for various English cities. They revealed that in Greater London, Liverpool, Birmingham and Newcastle a 10 percentage point difference in GCSE performance resulted in a 1 percentage point increase in house price. This was 2 percentage points in Greater Manchester and Leeds and 3 percentage

points in Bristol. They argued that this was a reflection of the local supply of school quality, with the greatest capitalisation of school quality in house price occurring in cities that have the lowest average exam pass rate (Glen and Nellis, 2010). Cheshire and Sheppard (2004) showed that a 1 standard deviation increase in test score lead to a 7.1% increase in house price although in effect they showed that school quality only commanded a substantial price in the top third of good schools. They also showed that the effect of school quality was associated with the suitability of family housing with bigger houses benefitting more. This was similar to the finding by La (2015) in the US where a 1 standard deviation increase in test score lead to a 3% increase in house price overall but this increase being 7% for houses with two or more bedrooms.

3. Methodology

3.1 Multi-level repeat sales approach

Most studies investigating the capitalisation of school quality into houses prices use the hedonic approach, on which there is an extensive literature - see Glen and Nellis

(2010) for a recent review. A key methodological issue using this approach is isolating the impact of school quality on house prices from the impact of neighbourhood quality. This endogeneity problem is caused by higher class neighbourhoods tending to have better schools due to pupils coming from family backgrounds that provide the resources and environment to do well academically and is an outcome of the residential sorting and cultural capital discussed earlier. There are various methodological solutions to this problem. One is to include all the relevant neighbourhood quality variables but it is not always possible to identify these *a priori* or measure them precisely (Orford, 2002) and so there is always the risk of omitted variable bias leading to upwardly biased estimates of the effect of school quality on house prices. Another common approach is to control for neighbourhood quality by comparing proximate properties on either side of a catchment area boundary and so exploit boundary discontinuities (eg Davidoff & Leigh, 2008; Nguyen-Hoang and Yinger, 2011). The assumption here is that the properties will share the same neighbourhood quality but pupils will attend different schools depending upon the catchment area in which they live. This assumption works well in jurisdictions where living in a catchment area guarantees a place (e.g. La, 2015) but would work less well in England where catchment areas are porous and where *de facto* catchment areas based on distance dominate the selection process of the most popular schools (Singleton et al., 2011). It

also assumes that neighbourhood quality does not change at catchment area boundaries, an assumption which may not always hold especially if catchment area and neighbourhood boundaries are congruent. Other approaches include the use of instrumental variables which are not correlated with neighbourhood quality but are a reflection of school quality such as the frequency of Government inspections (Rosenthal, 2003; Gibbons and Machin, 2003); or the use of natural experiments such as comparing house price differentials before and after the re-drawing of catchment area boundaries (e.g. Bogart and Cromwell, 2000; Allen et al., 2012).

An alternative methodology to the hedonic approach that can address the endogeneity problem, and the one that is used here, is the repeat sales method. This was introduced by Bailey et al (1963) and is based on analysing the growth rate of the price of all properties that were sold twice in a given time period and has been used in several similar studies (Leishman and Watkins, 2002; Rosenthal, 2003; Nguyen-Hoang and Yinger, 2011). The index can be constructed without needing much attribute information about the individual property which is an advantage in England where a complete set of attributes for all properties transacted on the market are generally not available. As the method uses a quasi-panel set of data rather than cross-sectional

data used in hedonic analysis, it controls for confounding factors such as neighbourhood quality and other attributes of the property mix by using fixed effects through time rather than including these factors as individual variables as in the hedonic approach (Nguyen-Hoang and Yinger, 2011). The key assumption of time fixed effects is that the attributes of the property and location will not have changed significantly between sales. This assumption works well when the period between sales (the holding period) is short, but over a longer period of time, it is unlikely that this will be the case and the repeat sales method becomes less effective. For instance, wealthier households moving into an area over time could have a positive effect on housing quality, neighbourhood quality and ultimately local school results, leading to the endogeneity effect described earlier. Therefore this study uses a short holding period between pairs of sales to reduce this effect, so any change in price can be associated with the general trend of house price change within the market and some attribute of the property that causes its house price to deviate from this overall trend (Case and Shiller, 1987). It is hypothesised that a growing demand to be located near a good school in terms of both distance and catchment area will be reflected in the short-term deviation in house price from this overall trend. The analysis will follow a natural experiment approach where measured differences in school quality through time will be used to capture and quantify these deviations and hence estimate the

price paid to locate near a school. The methodology is novel in respect it uses a multi-level specification of the repeats sales equation, with the second level being the catchment area of the school in which the property is located. If as discussed earlier, the demand for school places is such that buyers will outbid each other to locate in particular catchment areas, then these will act as submarkets with different supply and demand functions resulting in the implicit price of catchment areas varying across the county (Orford, 2000). The multi-level specification allows these catchment area level implicit price estimates to be calculated, after controlling for property attribute mix using time-fixed effects and factors such as changes in school quality and demand for school using variables described in the next section. Models for the three types of school (boys' and girls' grammar and all ability schools) will be estimated separately and, for each school, models will be estimated for all houses and then for each of the house types described later.

The full multi-level model specification is shown in equation (1), where the property is level 1 (i) and catchment area is level 2 (j) and time dummy variables (D_{tij}) are included in the fixed and random effect parts of the model

$$\ln(Pt_{1ij} / Pt_{0ij}) = \beta_{0j} + \beta_{1t}D_{tij} + \beta_{2m}X_{mij} + \mu_{(j)} + \tau_{(j)} D_{tij} + \varepsilon_{(ij)} \quad (1)$$

where i = 1,…, 3400 properties; j = 1,…, J catchment areas (J = 11 for boys' grammar schools; J= 12 for girls' grammar schools; J = 21 for all ability schools); t = 1,…, 6 years; m = 1, …, 6 predictor variables

$\ln(Pt_{1ij} / Pt_{0ij})$ is the natural log of the ratio of the resale price in t_1 over the initial sale price in t_0 for property *i* within catchment area *j*;

D_{tij} is a dummy variable with a value of -1 in the year of the initial sale t_0 ; 1 in the year of resale t_1 ; 0 otherwise;

X_{mij} is a predictor variable;

β are the fixed effect parameters to be estimated;

$\mu_{(j)}$, $\tau_{(j)}$and $\varepsilon_{(ij)}$ are the random parameters to be estimated that represent the variation of price between catchment areas and between properties within a catchment area and are assumed to be normally distributed with zero mean and unknown variances σ^2_i and σ^2_j respectively.

There are number of issues with the approach. It does not include new properties which may command a premium and the index will be weighted more towards those properties that are traded most often and this can lead to biases as they may not be representative of the entire stock. It is unable to capture changes in the property between transactions such as home improvements and depreciation or changes in locational attributes such as a decline in neighbourhood quality which may also lead to biased estimates. As described later, we try to control for the latter by only examining properties over a six year time period and removing properties that have an unusual change in house price or were transacted over a very short holding period.

3.2 The Buckinghamshire case study

3.2.1 Background to schools and school quality

Buckinghamshire is a county of just over half a million people to the north-west of London with a predominantly rural north and a more urban south – see Figure 1. It is part of the London commuter belt and is one of the most expensive places to buy a

house in the UK, with house prices the fourth highest outside of London. It is only one of a few authorities in England which has retained the traditional grammar school system along-side all ability state schools. It also has very strong demand by parents for children to be admitted to good schools, and particularly the grammar schools, with Harris and Rose (2013) showing that grammar schools in Buckinghamshire advance the educational prospects of their pupils whilst the selective system reduces the probability of exam success for those attending the county's all ability schools. Estate agent material for Buckinghamshire will often publicise when a property is located in popular school catchments and interviews with local estate agents (not reported here) suggest that school catchment areas, and particularly grammar school catchment areas, are a key factor for households with children in deciding where to live. Hence, it is an ideal location to study the extent to which school quality, and in particular the difference between grammar and all ability schools, are capitalised into house prices. The time period for the study is the six years between and 2010 – 2015. School statistics for 2010 and 2014 will be used to measure change in school quality over time. The 2015 statistics were not used as these would not have been published in time to affect the majority of buyers' decisions.

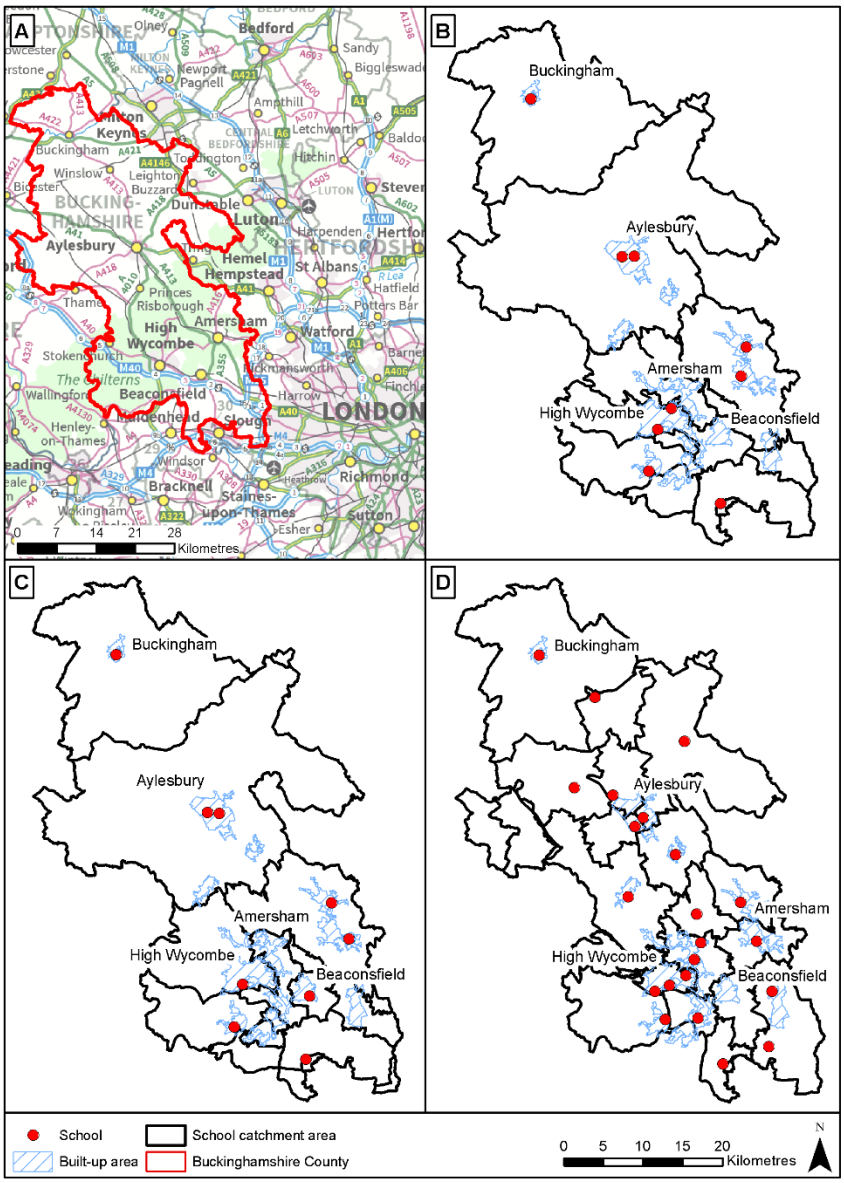


Figure 1 (A) Buckinghamshire in relation to London; (B) Boys' grammar school catchment areas; (C) Girls' grammar school catchment areas; (D) All ability school catchment areas. Contains OS data © Crown copyright and database rights 2018

Buckinghamshire has 13 academically selecting grammar schools; 4 are boys only, 4 are girls only and the rest (5) are mixed-sex meaning that male and female pupils have a total choice of 9 grammar schools each. In the text, boys' (girls') grammar schools refer to the 4 single sex and 5 mixed-sex grammar schools that boys (girls) can attend. The remaining 22 state schools are all ability mixed-sex upper schools. School catchment area boundary data was obtained for Buckinghamshire in GIS format in three separate layers shown in Figure 1: Boys' Grammar Schools (B), Girls' Grammar Schools (C) and All Ability Schools (D). Table 1 summaries the number of schools that fall into each catchment area by school type and reveal that many catchment areas contain more than one school, especially the grammar schools. Boys' and girls' grammar schools have 11 and 12 catchment areas respectively; 6 catchment areas serve two or more boys' grammar schools and 7 catchment areas serve two girls' grammar schools. The majority of all ability schools are served by single catchment areas, although 5 catchment areas serve two or more schools resulting in 21 catchment areas overall.

	Number of Schools in Catchment Area			Catchment Areas outside of Buckinghamshire
	1	**2**	**3**	
Boys' Grammar	5	4	2	3
Girls' Grammar	5	7	0	4
All Ability	16	4	1	2

Table 1 Number of Catchment areas by School Type

The result is a complex, messy geography of catchments with substantial overlapping and fragmentation which is similar to other places in England (eg see Harris et al. 2016 for London). The catchment areas of two all ability schools governed by neighbouring Oxfordshire county council that fall within Buckinghamshire are ignored as are parts of catchment areas that fall outside of the county. In 2014 OFSTED rated all but one of the grammar schools as Outstanding (the other was Good). Only one of the all ability schools reached this top rating, with the majority (13) being rated as Good and the remaining (8) rated as Requires Improvement. No school in Buckinghamshire was rated as Inadequate.

Most studies of the effect of schools on house prices have used test scores as a measure of school quality, and in England this is usually the percentage of children with 5+ GCSE A*-C (e.g. Glen and Nellis, 2010; Burgess and Briggs, 2010). As parents are likely to use a proven track record of school performance and for this to be reflected in house purchases (Glen and Nellis, 2010; Gibbons and Machin, 2003), GCSE results between 2010 and 2014 were used. Table 2 reports the percentage of pupils gaining at least 5 GCSEs grade A*-C including English and Maths in 2010 and 2014 and the difference between the two years. On average, this was almost 100% in grammar schools but only around 50% in the all ability schools. There had been very little change over the time period, although there was a slight average improvement in the grades of pupils in all ability schools. Although grammar schools are very similar, there is a large variation between all ability schools with a standard deviation of 10% and a range from around a third of pupils to over three quarters of pupils achieving these grades.

	% GCSE A*-C Inc. English and Maths 2014				% GCSE A*-C Inc. English and Maths 2010				% GCSE A*-C Inc. English and Maths 2014-10			
	Min	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**
Boys' Grammar	97	100	98.2	1.1	97	100	98.8	1.2	-3	3	-0.6	1.8
Girls'Grammar	97	100	99.1	1.2	97	100	99.0	1.0	-2	3	0.1	1.4
All Ability	35	77	52.3	10.6	26	72	48.9	10.7	-14	18	3.4	6.9

Table 2 Key GCSE results for 2010 and 2014

Another metric often used to measure school quality is the percentage of children eligible for free school meals (FSM) arising from receipt of state welfare benefits (Allen et al, 2012; Burgess and Briggs, 2010). Table 3 reports the percentage of pupils eligible for FSM in 2010 and 2014 and the difference between the two years. On average, less than 2% of pupils in grammar schools were eligible for FSM and this is over 8% in all ability schools and again there is a wide variation here ranging from less than 5% to around one fifth of pupils. There has been a very small average increase in the percentage of pupils eligible for FSM in grammar schools and a slight decrease in all ability schools over the time period.

	% Pupils FSM 2014				% Pupils FSM 2010				% Pupils FSM 2014-10			
	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD
Boys'Grammar	1	4	1.7	1.3	0	4	1.4	1.2	-1	1	0.5	0.6
Girls' Grammar	1	4	1.8	1.2	1	4	1.8	1.2	-1	1	0.3	0.6
All Ability	3	20	8.8	5.0	3	27	9.8	6.7	-7	2	-0.9	2.0

Table 3 Pupils eligible for free school meals for 2010 and 2014

Obviously, parents do not just use test scores in deciding the quality of a school but also other factors such as reputation, quality of sporting and other facilities, or the cultural or faith environment (eg Gibbons and Machin, 2003; Leech and Campos, 2003). Although Cheshire and Sheppard (2004) showed that these value added measures of school quality did not significantly affect house prices in England, they will be reflected upon when interpreting differences that schools have on house prices in the county.

3.2.2 Admissions policy and distance criterion

Buckinghamshire County Council publishes the admission policy for all state schools in the county, with criteria being ranked in order of importance. The top criterion for all types of schools is children who live in care. Living in the catchment area tends to be

the second criterion for all ability schools and third for grammar schools which tend to prioritise pupils who are eligible for free school meals. Siblings being on the school roll tend to be the next criterion, although as Hamnett and Butler (2011) observe, this is a quasi-geographical criterion given that most siblings reside together and unless they have since moved house, older siblings must have satisfied the geographical criteria to have been admitted. Distance from home to the school tends to be used as a deciding criterion when the school is over subscribed and pupils meet all the other criteria. Boys' and girls' grammar schools had an average distance cut-off of around 20 km from home to school whilst this was just under 6 kilometres for the all ability schools reflecting the larger number of all ability schools and their smaller catchment areas. There was a wide variation in the range of distance thresholds in the grammar schools from around 10 kms to nearly 30 kms for boys' grammar schools and 6 kms to over 30 kms for girls' grammar schools. The range was much smaller for all ability schools as expected.

Table 4 summaries the outcome of the allocation process for schools in 2014. Metrics such as the percentage of applicants to places (over-capacity) and surplus applications can measure the popularity and performance of the school beyond test score results –

full schools could be a good quality signal to parents and encourage demand (Gibbons and Machin, 2006; Hamnett and Butler, 2011). Only 8 of the all ability schools offered places to all of the pupils who applied. The remainder, including all of the grammar schools, offered places based on the criteria outlined above. Nearly all grammar schools had 100% of their applications being from first preference pupils but this varied with some all ability schools struggling to get more than two-thirds of their applications from first preference pupils and others having around 120% of applications being first preference – for one school this figure was 161. In terms of surplus places, the majority of grammar schools had filled all their places and of the six which had spare places these represented less than 3% of the total. All ability schools had more spare places with two schools having over a third of their places left to fill.

	% pupils in catchment allocated 1st preference				No. First Preference as a % Admission number				%surplus places			
	Min	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**
Boys' Grammar	92	100	98.6	2.8	81	123	98.1	14.9	0	3	1.3	1.4
Girls' Grammar	98	100	99.7	0.7	88	122	99.6	10.2	0	3	0.8	1.3
All Ability	93	100	98.8	2.0	46	161	93.7	26.8	0	43	4.9	11.1

Table 4 Summary of allocation process for school places by school type in 2014

3.2.3 Data

The England and Wales Land Registry supplied Price Paid Data for house price transactions. The data contains the full address of the property; the sales price; the date when the sale was completed; property type (detached, semi-detached, flat, terrace and other); whether the property is new build or an established building; the tenure (freehold or leasehold); and type of Price Paid transaction. There were around 50,000 property transactions in the Land Registry database for Buckinghamshire between 1st January 2010 and the 31st December 2015. These were geo-referenced to the Ordnance Survey National Grid using the National Statistics Postcode Directory that assigns the postcode of each property a grid reference of the postcode centroid to a precision of one metre. Only 37 were unable to be matched due to missing postcode information. The remainder were cleaned to remove transactions that had not been sold for full market value and where there were missing information leaving 48,758 properties. Just over 4100 or 8.4% properties had been sold more than once in this time period. It is recommended (Clapp and Giacotto, 1998; Steele and Goy, 1997) to remove re-sales that occur over a very short holding period as these might be atypical and could be sales due to job loss or renovation and often show relatively strong price increases (Jansen, et al 2008). The subset of repeat sales was therefore cleaned to remove all the properties that had been sold twice within one year (13.5%), those

which had a different house type recorded between sales (2.8%) and a very small number where statistical analysis of the data indicated that there may be an issue with accuracy of the data leaving 3400 repeat sales records (7% of all sales).

GIS was used to assign each property to the three catchment areas based on unit postcode. There is an average of 309 repeat sales observations in boys' grammar school catchments, 283 in girls' grammar school catchments and 142 in all ability school catchments. In the sample, the holding periods of 50% of repeat sales were within 2 years and 9 months and 75% were within 3 years and 9 months. Only 5% of repeat sales had holding periods that were between 5 and 6 years. Thus the holding period between sales is relatively short, minimising the endogeneity effect described earlier.

Six school variables were included in the analysis to capture any change in school quality and the demand for places over the time period (Chen & Harding, 2016): a dummy variable for whether the grammar school was single sex (**SingleSex**); the difference in the percentage of pupils gaining at least 5 GCSEs grade A*-C including English and Maths (GCSE) between 2010 and 2014 (**DIFGCSE14-10**); the difference in

the percentage of pupils eligible for free school meals (FSM) between 2010 and 2014 (**DIFFSM14-10**); number of first preferences as a percentage of total admissions in 2014 (**FirstPref14**); percentage of pupils who were allocated their first preference school and lived in the school's catchment area in 2014 (**Catch14**); percentage of surplus places in 2014 (**Surplus14**). If there were two or more schools in the catchment area, the average of the metrics was calculated. Averaging away the differences between two or more very different schools in a catchment area could be a problem but was found not to have occurred for grammar schools where the values of the school metrics tended to be similar, and only occurred in 1 of the 5 all ability school catchments which served more than one school. Subsequent analysis of the results did not reveal anything unusual or of interest about this catchment.

As the distance of a house to a school is an important admissions criterion for most of the schools, distance was incorporated explicitly into the calculation of the GCSE and FSM school variables. Following Gibbon and Machin (2006), the inverse Euclidean squared distance from a house to a school ($1/d^2$) was used so that distance to school is important but becomes less so with increasing distance from the school. If a catchment area had two or more schools, then the proportion of this distance to each

school was calculated. Finally, in order to account for commuting to London, the Euclidean distance to the nearest railway station was calculated (**Dist**). Although the repeat sales method would capture the effects of commuting (and other locational externalities) if these had not changed during the time period, it is probable that there had been an increase in the amount of commuting from Buckinghamshire to London due to households relocating out of London since 2010 and therefore an increase in demand for housing close to railway stations.

4. School catchment area price estimates

Two sets of multi-level catchment area models were estimated for each school type and house type; the full effects model which contains year dummy variables in the fixed and random parts and the contextual effects model which is the same as the full effects model but with the remaining variables included in the fixed part. For brevity, only the contextual effects models are reported in Tables 5-7 and only the 2015 year dummy variable (2010 being the reference year). Percentage changes in price can be obtained by taking the exponents of the estimated coefficients. All the data assembly and modelling was undertaken using the R software package (R version 3.4.2).

4.1 School metric price estimates

Table 5 reports the boys' grammar schools models. Semi-detached has the strongest relative house price increase over the time period, being 18% more expensive in 2015 compared to 2010. This compared to around 12% for detached houses and flats over the same time period. Single sex school is only significant for detached houses which increased price by 3.2%. None of the school variables were significant for flats and terraces. The differences in percentage of pupils gaining at least 5 GCSEs between 2010 and 2014 have a significant positive effect on all house prices resulting in an increase in price of 1.3% and this was just over 2% for detached and semi-detached houses. The differences in percentage of students eligible for free school meals over the time period also has a significant positive effect on all house prices with an increase overall of around 5% whilst this was 7% for detached houses. Variables measuring school admissions were insignificant in all models with the exception of first preferences places which were significant for all houses and detached houses and had a small effect of increasing house price by 0.5% and 0.8% respectively for every 1% that the school was oversubscribed. The variable measuring the percentage of pupils who were allocated their first preference school and lived in the school's catchment area was significant for all houses and this was negative suggesting that houses

become more expensive (by 0.4%) in catchment areas where pupils are less likely to be admitted to their first preference school, again representing a measure of demand. Finally, distance to the nearest railway station was negative and significant for all houses and flats representing a decline in price of 0.4% and 1% respectively per kilometre.

	All Houses			Detached			Semi-detached			Flat			Terrace		
	B	**SE**		**B**	**SE**		**B**	**SE**		**B**	**SE**		**B**	**SE**	
Year2015	0.170	0.016	*	0.120	0.034	*	0.180	0.022	*	0.11	0.03	*	0.148	0.029	*
SingleSex	0.007	0.007		0.032	0.016	*	-0.005	0.013		0.01	0.01		-0.008	0.011	
DIFGCSE14-10	0.013	0.004	*	0.021	0.010	*	0.022	0.006	*	0.01	0.01		0.008	0.005	
DIFFSM14-10	0.048	0.015	*	0.069	0.035	*	0.054	0.024	*	-0.02	0.03		0.043	0.023	
FirstPref14	0.005	0.002	*	0.008	0.004	*	0.002	0.003		0.00	0.00		0.005	0.003	
Catch14	-0.004	0.002	*	-0.006	0.004		-0.001	0.003		0.00	0.00		-0.004	0.003	
Surplus14	-0.005	0.004		-0.005	0.009		-0.002	0.006		0.00	0.01		0.007	0.006	
Dist	-0.004	0.001	*	-0.005	0.004		-0.003	0.002		-0.01	0.00	*	-0.001	0.002	
Residual	0.27	0.16		0.04	0.21		0.020	0.143		0.139	0.118		0.015	0.121	
AIC	13090			-148			-871			2486			-1215		

* Significant at 5% level

Table 5 Boys' grammar schools contextual effects multi-level models

Table 6 reports the girls' grammar schools models. The relative price increases between 2010 and 2015 are similar to boys' grammar school catchments with the exception of detached houses where the increase is 20% compared to 12% and terraces where the increase is 21% compared to 15%. The single sex school variable is significant for all houses and detached houses and increases the price by 2.6% and 1.8% respectively, the latter being only half of the size of the increase associated with boys' grammar school catchment areas. Very few of the school variables were significant across the models. The differences in percentage of pupils gaining at least 5 GCSEs between 2010 and 2014 have a significant positive effect on all house prices, resulting in an increase in price of 1.1% and this was just over 1.5% for detached and semi-detached houses, thus being slightly less than the increase in boys' grammar school catchments. The only measure of school admissions that was significant was first preferences places and this had a very small effect of increasing all houses and detached house prices by around 0.1% for every 1% that the school was oversubscribed. Distance to the nearest railway station had no significant effect on house prices.

	All houses			Detached			Semi-detached			Flat			Terrace		
	B	**SE**		**B**	**SE**		**B**	**SE**		**B**	**SE**		**B**	**SE**	
Year2015	0.181	0.020	*	0.203	0.056	*	0.202	0.028	*	0.107	0.030	*	0.209	0.052	*
SingleSex	0.026	0.013	*	0.018	0.009	*	0.020	0.020		-0.018	0.019		0.008	0.017	
DIFGCSE 14-10	0.011	0.006	*	0.016	0.007	*	0.015	0.007	*	0.009	0.011		0.005	0.008	
DIFFSM1 4-10	0.036	0.023		0.073	0.058		0.008	0.036		0.031	0.038		0.048	0.031	
FirstPref 14	0.001	0.001	*	0.001	0.000	*	0.001	0.001		0.001	0.001		0.001	0.001	
Catch14	-0.001	0.001		0.000	0.002		0.000	0.001		0.000	0.001		0.000	0.001	
Surplus14	-0.001	0.002		-0.007	0.006		-0.001	0.004		0.000	0.004		-0.002	0.003	
Dist	0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000	
Residual	0.03	0.16		0.04	0.21		0.02	0.14		0.02	0.13		0.02	0.13	
AIC	-2610			-123			-879			-805			-1133		

* Significant at 5% level

Table 6 Girls' grammar schools contextual effects multi-level models

Table 7 reports the all ability schools models. The relative price increase between 2010 and 2015 are similar to boys' and girls' grammar schools with the exception of detached houses with an increase of 14% which is different from the 20% for girls' grammar schools, and terraces with an increase of 18% which falls in between 15% for boys' and 20% for girls' catchments. In contrast to the grammar school models, none of the school metrics were significant for detached houses and very few were significant in the remaining models. The differences in percentage of pupils gaining at least 5 GCSEs between 2010 and 2014 was significant but negative for all houses and terrace houses suggesting a decrease in price of 0.2% and 0.3% respectively with every 1% increase in the number of pupils achieving the grades. This is a reflection of the largest improvements being in those schools with the lowest pass rates in 2010 and therefore still having relatively low pass rates in 2015. The differences in percentage of students eligible for free school meals over the time period has a significant negative effect on semi-detached house prices with a decrease of around 1%. The only measure of school admissions that was significant was the variable measuring the first preference places in the school's catchment area which, apart from detached, was significant and 0.1% for all of the house types. This suggests that the price of houses have increased more where it is more likely that pupils will be admitted to their first

preference catchment area school although the increase is minor. This contrasts with the boys' grammar school

	All houses			Detached			Semi-detached			Flat			Terrace		
	B	SE		B	SE		B	SE		B	SE		B	SE	
Year2015	0.155	0.017	*	0.134	0.046	*	0.188	0.022	*	0.099	0.028	*	0.176	0.024	*
SingleSex															
DIFGCSE14-10	-0.002	0.001	*	-0.001	0.002		0.000	0.001		-0.003	0.001		-0.003	0.001	*
DIFFSM14-10	-0.002	0.004		-0.009	0.009		-0.011	0.004	*	-0.002	0.005		-0.004	0.005	
FirstPref14	0.000	0.000		0.001	0.001		0.000	0.000		0.000	0.000		0.000	0.000	
Catch14	0.001	0.000	*	0.001	0.001		0.001	0.000	*	0.001	0.000	*	0.001	0.000	*
Surplus14	-0.001	0.001		-0.001	0.002		-0.001	0.001		-0.001	0.001		-0.001	0.001	
Dist	0.000	0.000	*	0.000	0.000	*	0.000	0.000	*	0.000	0.000		0.000	0.000	*
Residual	0.04	0.21		0.04	0.21		0.02	0.14		0.02	0.14		0.02	0.13	
AIC	-2513			-104			-858			-761			-1095		

* Significant at 5% level

Table 7 All Ability schools contextual effects multi-level models

catchment areas where prices increased more in those catchment areas where it was less likely that the pupil will be admitted to their first preference catchment area school, possibly reflecting greater competition for places. Distance to the nearest railway station had a significant effect on house prices, except flats, but the effect was extremely small.

4.2 School Catchment Price Differentials

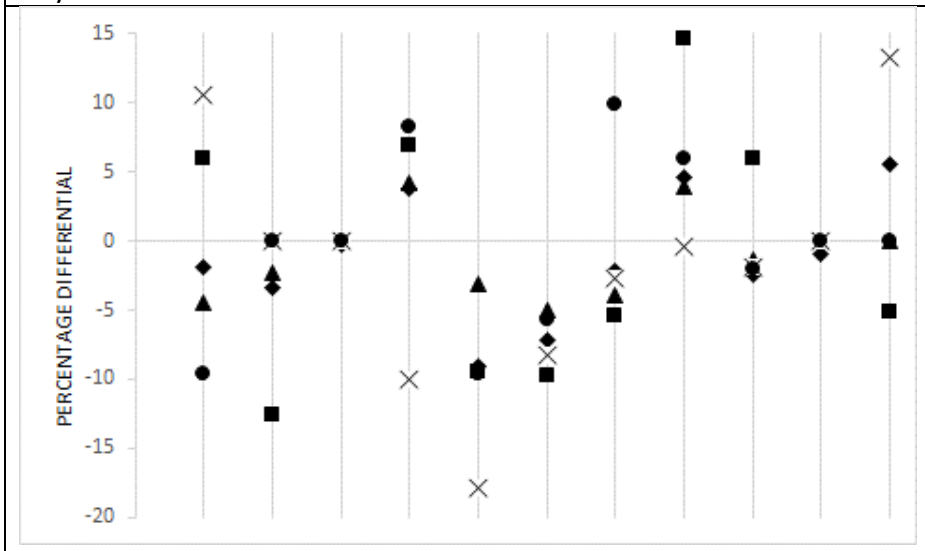
The full effects and contextual effects models were used to estimate the price differentials of buying in a particular catchment area for each house and school type. Level-2 School catchment area repeats sales indexes for 2015 were estimated and the ratio with the Buckinghamshire wide 2015 repeat sales index calculated. These ratios were then multiplied by the average house price for Buckinghamshire for 2015 to estimate the average house prices for each catchment area. Percentage price differentials from the Buckinghamshire average were also calculated. House price differentials for two all ability school catchment areas which had fewer than 30 repeat sales were ignored as these estimates may not be robust. The full effects model estimates represent the price differential of buying a house in the catchment area in 2015 compared to the Buckinghamshire average. The contextual effects model adjusts these estimates for school exam performance and demand for places and thus could be interpreted as the price differential for other aspects of the school, such as reputation. Generally we would expect the full effects model price estimates to be greater than the contextual effects model price estimates for each catchment as the latter will reflect the price after adjusting for factors such as GCSE scores and demand for places.

Figure 2 is a summary of the catchment area percentage price differentials estimated by the two models for each school type. The vertical lines represent catchment areas with the symbols on each line showing the percentage difference in price of each house type from their average for Buckinghamshire. House types that cluster around the horizontal axis are similar in price to their Buckinghamshire average and thus no price differential exists. For boys' grammar school catchments, the full effects model shows that for all houses, most catchment price differentials are within 5% of the Buckinghamshire average. The largest premium is 5.5% (£23,000) above the average county price and this is for a catchment area which serves three single sex schools. The next highest premium is 4.5% (£19,000) and is a catchment area which serves two schools. Detached houses have the largest variation in percentage price differentials with the largest premium being almost 15% (£98,000) and largest discount being almost 13% (£84,000) compared to the county average. Flats also show large variation in price differentials with two catchment areas having premiums greater than 10% (around £25,000), one of them serving three single sex schools. There is very little variation in price differentials for semi-detached houses and terraces.

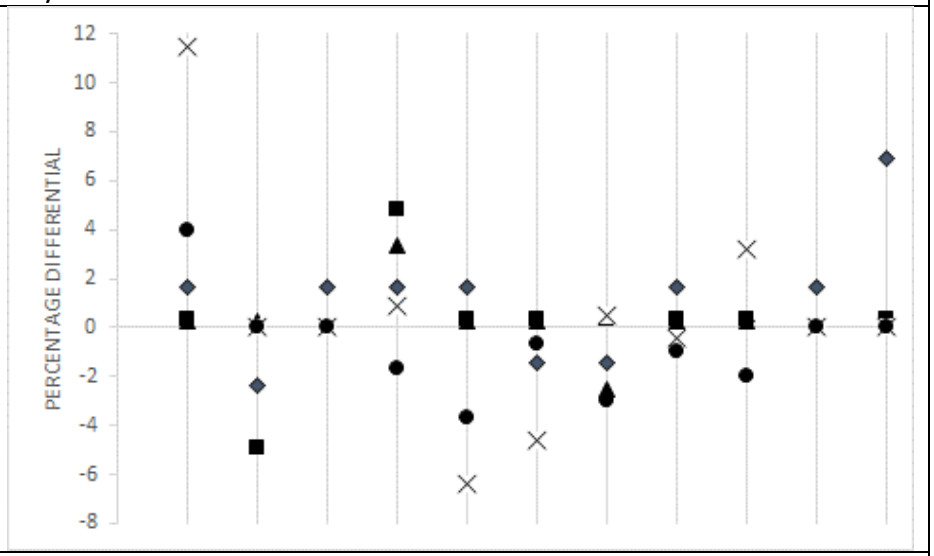
The contextual effects model shows that after the price differentials have been adjusted, there is little variation with most catchment areas being within 2% of the Buckinghamshire average. This suggests that differences in school catchment area prices are a function of exam performance and the demand for places. For all houses, the catchment area with the largest price differential after adjustment is 7% (£29,000) which again is for the three school catchment area perhaps reflecting the demand for extra choice. For detached houses, this is

5% (£32,000) and was for a school in a catchment where all first preference pupils tend to be admitted so perhaps reflects the reputation of the school beyond exam performance. In comparison, the largest discount (4.5% or £30,000) was for one of the most over-subscribed schools suggesting that prices were relatively cheaper in catchment areas where there was a reduced likelihood of being successful in getting into the school. The largest premium overall was 11% (£25,000) for flats in a catchment where all first preference pupils were admitted and there was a surplus of places

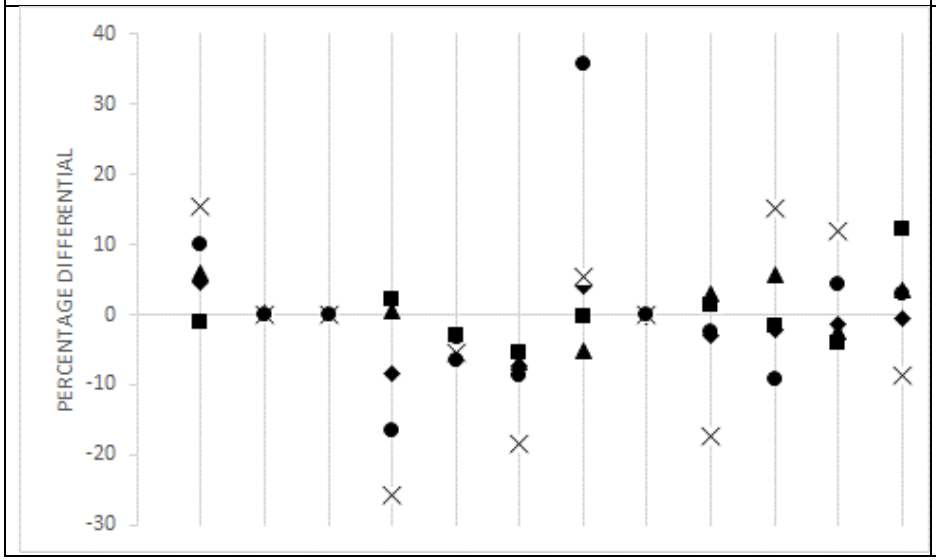
Boys' Grammar Schools Full Effects Model



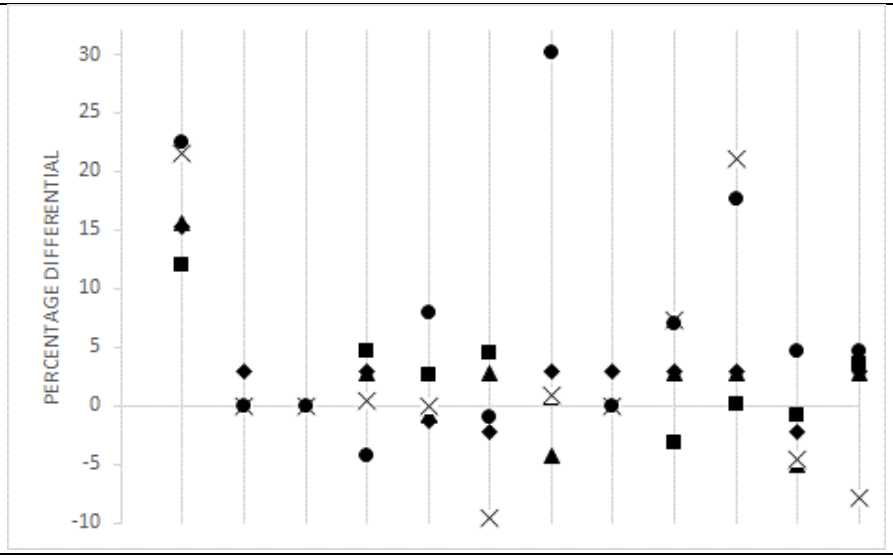
Boys' Grammar Schools Contextual Effects Model



Girls' Grammar Schools Full Effects Model



Girls' Grammar Schools Contextual Effects Model



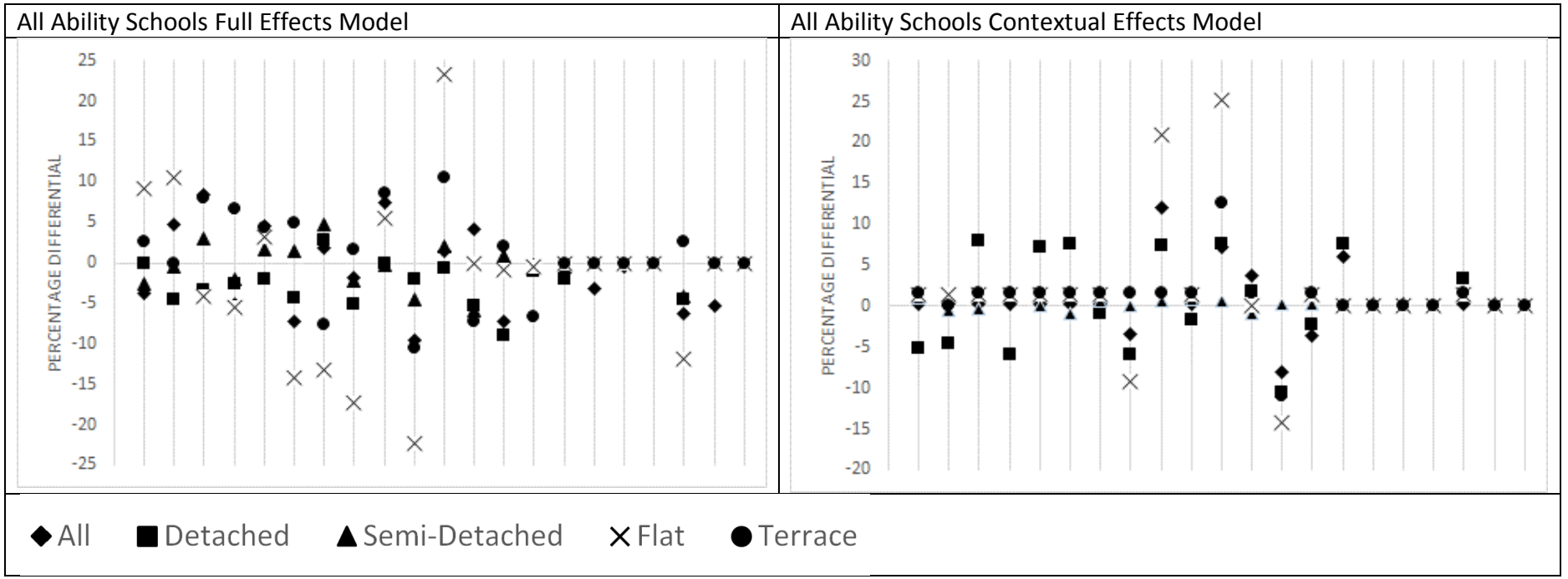


Figure 2 Percentage price differentials for catchment areas by school type and house type 2010-15

Similar to boys' grammar schools, the majority of price differentials of girls' catchment areas fall within 3% of the Buckinghamshire average, although there are some notable variations. Flats and terraces show the greatest variation in catchment area price differentials. For flats, three catchment areas have premiums between 12-16% (£26,000-£34,000) and these increase to 21% (£47,000) for two of them after adjustment. In one of these catchments all first preference pupils were admitted and there was a surplus of places; the other one is discussed below. Terraces follow a similar pattern with one catchment area having a premium of 36% (£108,000) reducing to 30% (£91,000) after adjustment (this was a catchment for two heavily over-subscribed schools) and a further catchment area premium increasing from 10-23% (£30,000-£68,000) after adjustment. One catchment area stands out has having large price differentials across all house types after adjustment with 15% (£64,000) for all houses, 12% (£80,000) for detached houses and 16% (£56,000) for semi-detached houses. The catchment is for a single school which is slightly over-subscribed although all first preference pupils in the catchment area were admitted. There is nothing notably different compared to other schools so the premiums may reflect additional features not captured by exam performance and demand for places.

For all ability schools, the majority of catchment area price differentials fall within 3% of the Buckinghamshire average and these fall to within 1% after adjustment thus buyers are paying less compared to grammar school catchments. For all houses the largest premium is 8% (£35,000) before adjustment with only one catchment area having a price difference over 10% (12% or £50,000) after adjustment. Both schools were not over-subscribed and had average exam performance scores. For detached houses, three catchments had

premiums of 8% (£51,000) after adjustment. These tended to have surplus places and slightly above average exam performance scores. Detached houses tended to have the largest premiums after adjustment of all houses types, perhaps reflecting the increase demand for family homes in good catchments. Flats have a wider range of catchment area price differentials, with the largest premium of 23% (£51,000) for a school with above average exam scores and surplus places, and for the two catchments areas discussed previously with premiums of 21% (£46,000) and 25% (£55,000) after adjustment. Terrace houses had a smaller range of catchment area price differentials than flats but larger than detached and semi-detached houses. The largest premium was 11% (£32,000) and this increased to 13% (£38,000) after adjustment and was the same catchment area as before. All the schools with the largest premiums were rated as Good by OFSTED in 2015. The catchment area of the only Outstanding all ability school did not have a large enough sample size of repeat sales to be included in the price differential analysis.

5. Conclusion

Using a novel multi-level specification of the repeat sales method, the research has demonstrated that school quality is capitalised into house prices differently in catchment areas for grammar schools compared to all ability schools and for boys' compared to girls' grammar schools. This effect is moderated by house type and changes in exam performances and demand for places. Not only do buyers pay more for houses in over-subscribed boys' grammar schools catchment areas in comparison to girls', but the

competition for places at boys' grammar schools is such that houses become more expensive the less likely a pupil will get a place thus revealing the effect on price by the demand for places. This is particular true for single sex boys' grammar schools which has an average premium twice as large as that for single sex girls' grammar schools for detached houses. In comparison, the effect of changes in exam results and admissions criteria on house prices in the catchment area of all ability schools is not only very small but also suggests that the demand for school places operates differently. Buyers are paying less to live in the catchment area of schools which have had an improvement in their exam performance but are paying more for houses in catchments where pupils are more likely to be admitted. The two may be connected with parents opting to live in catchment areas where they can better guarantee their first preference school thus avoiding improving schools where demand may be greater. Improving schools have traditionally had lower exam results on average and therefore a poorer reputation which will take time to change and be reflected in house prices. There is also some evidence that houses in multiple catchment areas command a higher premium and this is especially true for grammar schools. These school catchments tend to serve major population centres in the county and so this could be a reflection of the dynamics of the local housing market but it could also suggest that some buyers are spreading the risk in the admissions process by maximising their choice of schools - more research is needed. The research has also shown that prices of family homes, and especially detached houses, are affected the most by school choice and have the largest premiums supporting the findings by Cheshire and Sheppard (2004). However, there are also cases where flats command the highest premiums in certain catchments perhaps suggesting that parents are buying into an area where family houses are scarce or too expensive and flats are a cheaper alternative to get an address.

In terms of premiums, buyers paid up to 3% (pre-adjustment) more than the county average to live in all ability school catchments with good exam results and up to 5.0-5.5% (pre-adjustment) more to live in the boys' and girls' grammar school catchment areas, and this is in line with the findings of past research in the UK. The fact that most differences from the average vanish after adjusting for contextual variables shows that buyers are basing their decisions on school exam performance and are taking cues about quality from past demand for places. There are a small number of catchment areas where substantial price differentials remain and these could be a reflection of other factors that have not been captured in the models, such as reputation.

This research therefore adds to a small but growing body of work in the UK about how local housing markets can structure the access to state schools and hence its relationship with school choice, preference and educational attainment. As such, it can be seen as part of the wider discourse on educational mobilities and cultural capital (Waters, 2017) with the interplay of structure, such as social class, and agency, such as individual choice and movement, where middle-class families are willing and more able to move to access educational opportunities, in a way that less wealthy families are not. Given the on-going policy debates, and that recently the number of grammar school places (rather than schools) have increased with Government backing, more research is needed to understand the geographies of schools choice, educational attainment, and the housing system in the UK.

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