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Capitalizing Performance of 'Free' Schools and the Difficulty of Reforming School Attendance Boundaries

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Abstract

School attendance boundaries are a contentious issue in New Zealand, and have been relaxed and re-imposed depending upon political sentiment. Critics contend that a supposedly egalitarian state school system becomes one of selection by mortgage, with the value of 'free' schools capitalized into property prices. Attendance boundaries restrict the schooling opportunity set facing a student, who typically is unable to study at nearby high-performing schools if they live outside their boundary. We relate schooling opportunity sets to sales prices of over 8000 houses in Christchurch, controlling for dwelling attributes, neighborhood characteristics and geographic accessibility to a wide range of services. Our model explains over three-quarters of the variation in prices and we use this model to predict property prices if there were no attendance boundaries. Abolishing boundaries expands most schooling opportunity sets and predicted house prices generally rise. But prices would fall in some higher income neighborhoods with highly educated residents, who are likely to oppose reform of school attendance boundaries.

Keywords

attendance boundaries
house prices
school quality

JEL Codes

C21; I20; R21

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I. Introduction

Studies by economists in many places show that the value of 'free' public schools is capitalized into property prices (Cheshire and Sheppard 2005, Davidoff and Leigh 2008 and Machin 2011). These effects are likely to be especially strong in New Zealand, where publicly-funded schools have been self-managing for the last two decades and have the power to establish their own attendance boundaries – there are no school districts as in most other countries. These attendance boundaries restrict the schooling opportunity set facing a student, who typically is unable to study at nearby high-performing schools if they live outside their boundary.

These restrictions on schooling opportunities are likely to exacerbate socio-economic inequalities. The existing evidence from New Zealand is that schools in affluent areas adopt boundaries that protect them from unwanted lower socio-economic status students living within walking distance of the school (Thomson 2010, Lubienski, Lee and Gordon 2013). In particular, Maori and Pacific Island students are unlikely to attend high performing schools under selection by mortgage, where the price that parents are willing or able to pay for a house determines access, since these two ethnic groups have the lowest net worth (including dwelling wealth) of any groups in New Zealand (Scobie, Gibson and Le 2005). The evidence from other countries is that moving to open enrolment, where students can apply to any school without having to live in the school's catchment area, greatly weakens the effect of school performance on local house prices (Machin and Salvanes 2010). As such, reform of school attendance boundaries is expected to have desirable effects on inequality, as Lubienski *et al.* (2013, p.82) note:

> '…efforts to erase school attendance boundaries have the theoretical potential to open up opportunities for students from disadvantaged communities to choose schools other than their local school, based on academic quality rather than attendance zones.'

But whether such benefits actually follow from reforming school attendance boundaries depends on several factors that are currently unknown in New Zealand. First, the strength of the relationship between school performance and house prices is unknown; the existing New Zealand literature adopts more of a real estate approach, relating house prices to the attendance boundaries of particular schools while ignoring information on school performance. The second unknown concerns the likely strength of opposition to any reform of attendance boundaries. The evidence from elsewhere, using referenda on voucher-based schooling reforms, is that home owners in neighborhoods with good public schools are more likely to oppose reforms that would open up enrolments (Brunner and Sonstelie 2003).

In this study we provide evidence on both of these factors. We use sales prices of over 8000 houses in New Zealand's second largest city, Christchurch, to estimate the effect of school performance on house prices. Our data are from the mid-2000s, which is before a series of earthquakes beginning in 2010 altered Christchurch's property market and temporarily disrupted schooling.[1] Nevertheless, our key result that the effect of school performance on house prices is stronger than is typically found overseas should be representative of the present-day situation in other New Zealand cities.

Our hedonic house price model explains over three-quarters of the variation in prices and we use this model to predict property prices if attendance boundaries were abolished. Prices are predicted to rise for many houses but would fall in some higher income neighborhoods whose highly educated residents live inside attendance boundaries of schools with the best performance. The areas where house prices are predicted to fall would likely provide some of the strongest opposition to any proposed reform of school attendance boundaries. Since about one-half of the housing stock sells every decade, many owners will have a paid a premium that reflects the capitalized value of expected access to these schools with the windfall gainers being the owners when boundaries were set. These features of the property market make reform of school attendance boundaries difficult, even if there are gains in equity and the efficiency of the human capital investment process from moving to open-enrolment policies.

II. Policy Context and Previous Evidence

Historically only a minority of New Zealand schools had enrolment schemes that required use of attendance boundaries. After the baby boom cohort moved past school-age the usual pattern was one of declining enrolments (Beaven 2003). But over-crowding of schools became an emerging issue from the late 1980s as the children of the baby boomers approached secondary school age. Partly in response, the 1989 Education Act implemented the 'Tomorrow's Schools' reforms of the Fourth Labour Government which devolved school decision making powers and increased parental choice. Under these reforms, admissions policies were amended to allow students to attend any state school with space available, but children retained the right to attend a local school. The first year of reform implementation, in 1991, saw guaranteed access for students inside a school's attendance boundary and places for students outside boundaries were allocated by lottery (Harrison 2004). The center-right National Party was elected in late 1990 and they further extended schooling choice by abolishing all boundaries (or 'zones') with effect from 1992. Over-enrolled schools were then free to determine their own enrolment scheme provided it did not discriminate on economic, racial or religious grounds (Adams 2009).

[1] The 14 state secondary schools used in the analysis all continue to operate in the post-earthquake period but one or two may change location, while keeping within the broad neighbourhood, due to some buildings being condemned.

The election of the Fifth Labour Government in 1999 came during a period of reversal of the economic and social reforms of the 1980s. Even before this government was elected, legislation and policy had begun to weaken some of the reforms of Tomorrow's Schools. In 1999, legislation increased central regulation of enrolment schemes to ensure students could attend a 'reasonably convenient' school, in effect giving priority to those within a school's catchment area. The Education Amendment Act of 2000 required schools to enroll students living within an attendance boundary and allocate places to out-of-boundary students by ballot – returning to the situation in 1991 (Harrison, 2004). This Act also removed the bulk funding option for schools that had provided them with block grants, reintroduced capped rolls, and removed the discretion that schools previously had for determining their own enrolment scheme.

There is some previous research on school attendance boundaries and house prices in New Zealand but it is more in the nature of spatially limited case studies that are uninformative for policy. In each case, house prices have been related to dummy variables for whether a house was inside the school attendance boundary (or 'school zone') for particular schools. There is no measure of school performance in these studies so results cannot generalize to other settings and it is not possible to draw implications for improving school quality. In the first of these studies, McClay and Harrison (2003) examined sales prices for 500 properties in Northwest Christchurch and related these to dwelling characteristics and to a set of dummy variables indicating whether the dwelling was inside the attendance boundary for each of four schools. Since these boundaries overlap somewhat, seven dummy variables were needed to create exclusive categories, with an eighth used for dwellings outside the boundaries of all four schools. This study found the highest price premium was for being inside the attendance boundary of Christchurch Girls High School (CGHS); at $138,000 it was equivalent to almost 50 percent of the average house price. However, this study had no controls for neighborhood characteristics, and for the geographic attractiveness of locations, so this premium may be capturing many influences other than just the guaranteed access to a state school that is perceived to be of high quality.

A further concern with the McClay and Harrison study is that no account was taken of any spatial autocorrelation, which is a typical feature of real estate data. This cross-sectional dependence can arise because nearby properties share local amenities, and because suburbs tend to develop at the same time and so have dwellings of similar age, size, and construction materials. Also, buyers may decide how much to pay for a house based in part on the value of surrounding houses. An update of the Harrison and McClay study, using 670 house sales from Northwest Christchurch in 2004, found that the apparent price premium for CGHS fell by 62% once an appropriate spatial regression method was used (Gibson *et al*. 2007).

Rehm and Filippova (2008) examined house sales over a 21 year period for a small area of the Auckland suburbs at the confluence of the attendance boundaries for four state secondary schools, including the prestigious Auckland Grammar School. The hedonic regressions relating prices to dwelling attributes and location dummy variables were estimated for ten sub-periods (of two or three years each) that cover the relaxation and then re-imposition of school attendance boundaries. The results suggest that house prices appreciated more rapidly for a suburb that was added to the Auckland Grammar zone, after the reinstatement of boundaries in 2000. In contrast, the price premium fell for another suburb (Epsom South) at risk of being excluded from the Grammar zone in future if a rise in student numbers causes a smaller attendance boundary to be drawn (since roll numbers are capped), because this suburb is also inside the boundary of a less prestigious school.

While these findings from the previous New Zealand studies are of interest from a real estate point of view, there is little in them that can inform policy, except to make the point that house prices capitalize the forward-looking expectations of parents about access to schools that are perceived to be better or worse. Consequently, attendance boundaries are likely to be difficult to reform since most people living near to popular schools have already paid an ‘admission price’ and windfall gains are only for the owners at the time boundaries were changed. For example, in the data used below, just over four percent of houses sell every year, so a decade after school boundaries are introduced or reinstated about one-half of dwelling owners are likely to have paid a price that includes the capitalized value of expected access to a particular school. Any subsequent dilution of that right of access will see these owners lose some of the capitalized value of the ‘free’ schools. Just how large this effect is likely to be is shown below.

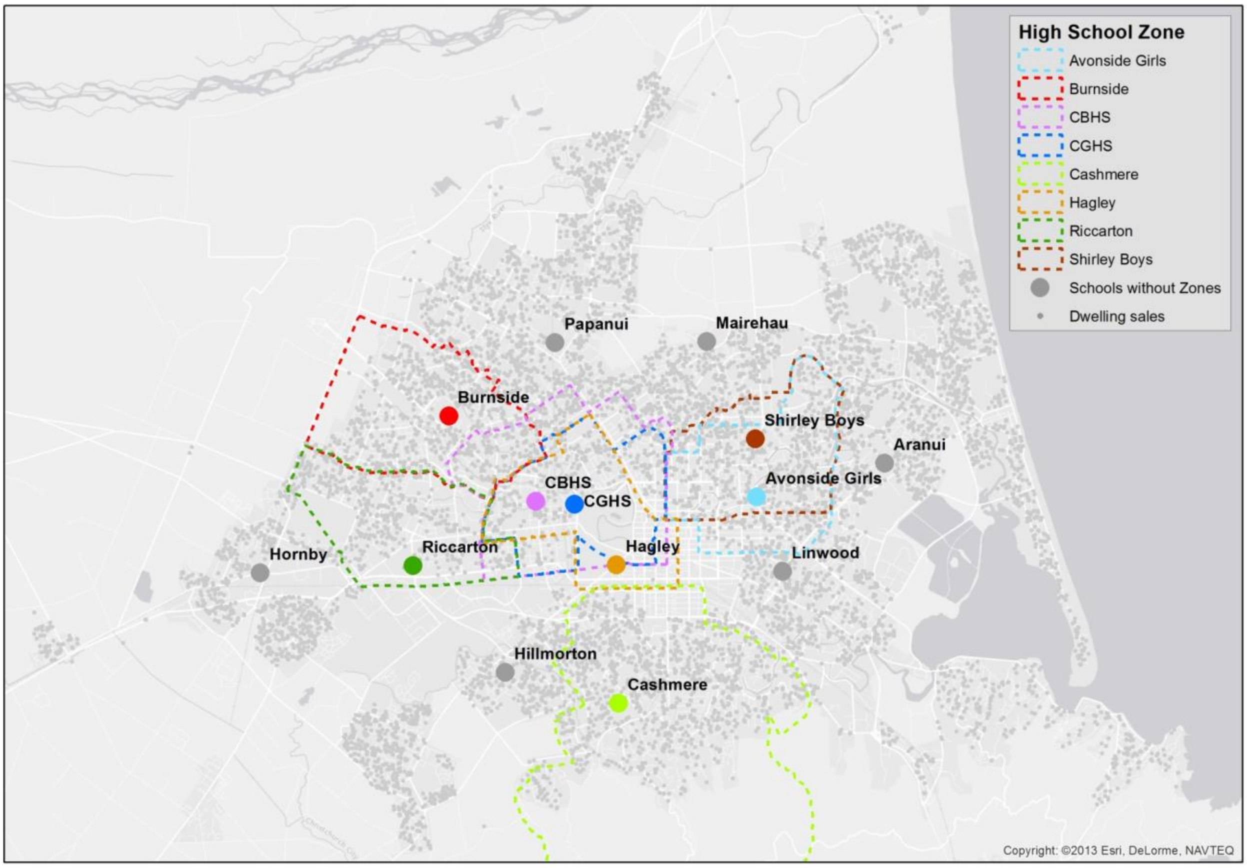
III. Data and Methods

A database was purchased from Quotable Value New Zealand (QVNZ) containing the sale price and dwelling characteristics for all detached houses sold in Christchurch between October 2004 and October 2005 (n=9169 sales). The characteristics included land and building area, building age, materials used in the roof and wall, parking spaces, type of garage, and whether there was a deck, a slope, or any view. The address of each property was also provided, along with a unique identification code for the land parcel, which enables merging with other geographic data. From this database we removed dwellings selling for less than 40 percent of their rateable value (n=39), which were felt to reflect either non-market influences or lack of arms-length transactions, and also removed dwellings with missing information on attributes used as explanatory variables in the model of house prices (n=311). The resulting database of n=8849 sales included 361 repeat sales where even within 13 months the same dwelling was resold. For the repeat sales the street address and land parcel codes are also repeated, and this violated our need for unique geographic coordinates to use for forming a spatial weighting matrix for the spatial regressions. Therefore, we dropped the earlier sale of any dwellings with repeat sales, leaving us with a database of n=8488 sales for unique properties.

The attendance boundaries for those secondary schools in Christchurch that impose them were obtained from Critchlow Associates, who maintain the boundaries database for the Ministry of Education.[2] The boundaries and dwellings data were overlaid onto a base map of Christchurch using a Geographic Information System (ArcGIS 9.1). Figure 1 shows the locations of the properties, the locations of the 14 secondary schools in Christchurch (excluding parochial and private schools) and the school attendance boundaries for the eight schools that impose them.

The smallest attendance boundary is for Girls High (CGHS), which lies everywhere within the boundary for Boys High, and the largest boundary is for Cashmere. The schools with attendance boundaries are generally near the middle of the city, with the schools that do not impose boundaries around the fringes (Burnside and Cashmere are exceptions to this pattern). There are more sample dwellings outside attendance boundaries (62 percent) than inside boundaries. Of those dwellings inside a boundary, most are within the boundary for a single school (but they are not precluded from attending a school that does not have a boundary). However, nine percent of dwellings are inside attendance boundaries for two schools, two percent are inside boundaries for three schools and a handful of dwellings are inside boundaries for four schools.

Figure 1: Locations of Schools, Attendance Boundaries and Dwelling Sales



2 See www.schoolzones.co.nz for details.

The other databases used provide information on neighborhood characteristics and on the geographic accessibility to a wide range of services for the census meshblock that the dwelling is located in.[3] The proportion of the meshblock usual residents who are of non-European ethnicity, who were born outside of New Zealand, (and for those age 15 and above) who have degree or higher education, who have no school qualifications, who are employed fulltime, and who are unemployed at the time of the 2006 Census is obtained from the database constructed by Clark and Kim (2012).

The Census data also provide the meshblock average home ownership rate, and the median household income. A meshblock level Gini index for personal income and the per capita rate of recorded crime offences as constructed by Clark and Kim (2012) also are used. The geographic accessibility variables come from a study by Pearce *et al*. (2007) which uses data on the location of different types of community resources (such as parks, emergency facilities, schools, shops, etc) over the 2002-2005 period and constructs road distances to the nearest facility amongst each type, for each meshblock in New Zealand. A total of 12 facilities are used here, to capture the overall geographic attractiveness of particular locations so that the school variables we use are not acting as a proxy for other omitted geographical features.

The impact of school attendance boundaries in restricting schooling opportunity sets can be seen in the example of two dwellings located near the centre of Christchurch (Figure 2). The example also provides some intuition for the way we model possible reform of attendance boundaries. The schooling opportunity set for the first dwelling is illustrated in Figure 2a, where solid arrows show the schools that can be attended for a student residing in that dwelling and the broken arrows show the schools for which that dwelling is outside the attendance boundary. Each arrow is a vector whose length and direction represents the actual straight-line distance from the dwelling to each of the 14 state secondary schools in Christchurch. For each school, the pass rate for the NCEA Level 3 examinations also is shown. Note that Level 3 pass rates are more variable across schools than Level 2 or Level 1 pass rates, and range from highs of 84% at Girls High (CGHS) and 73% at Burnside, to lows of 10% at Aranui and 24% at Mairehau.

The dwelling in Figure 2a is outside the attendance boundary of all schools with boundaries, so the schooling opportunity set consists only of the six schools without boundaries (shown by the six solid arrows). On average, the Level 3 pass rate for the six schools without attendance boundaries is 30%, versus 56% for the eight schools with boundaries. Hence, the opportunity set for a student residing here is limited. But the simple average pass rate for the six open-access schools is not the best estimate of the schooling

[3] New Zealand has almost 40,000 meshblocks, each with an average of just 110 residents. For an urban meshblock, if perfectly square the dimensions would be just over 200 meters, so this is a finely scaled spatial unit.

opportunity set for this location, since it treats a distant school like Aranui (7.6 km away) as equally important as a closer school, such as Hillmorton (2.2 km away).[4]

Figure 2a: Schooling Opportunity Set
for a Dwelling Outside Attendance Boundaries

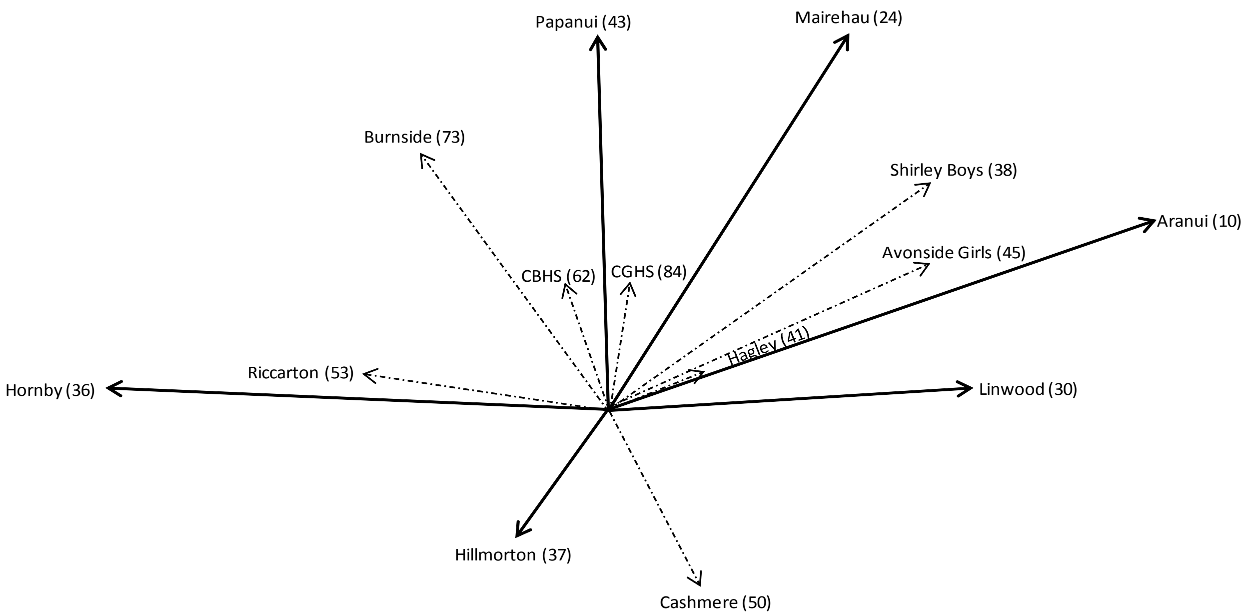
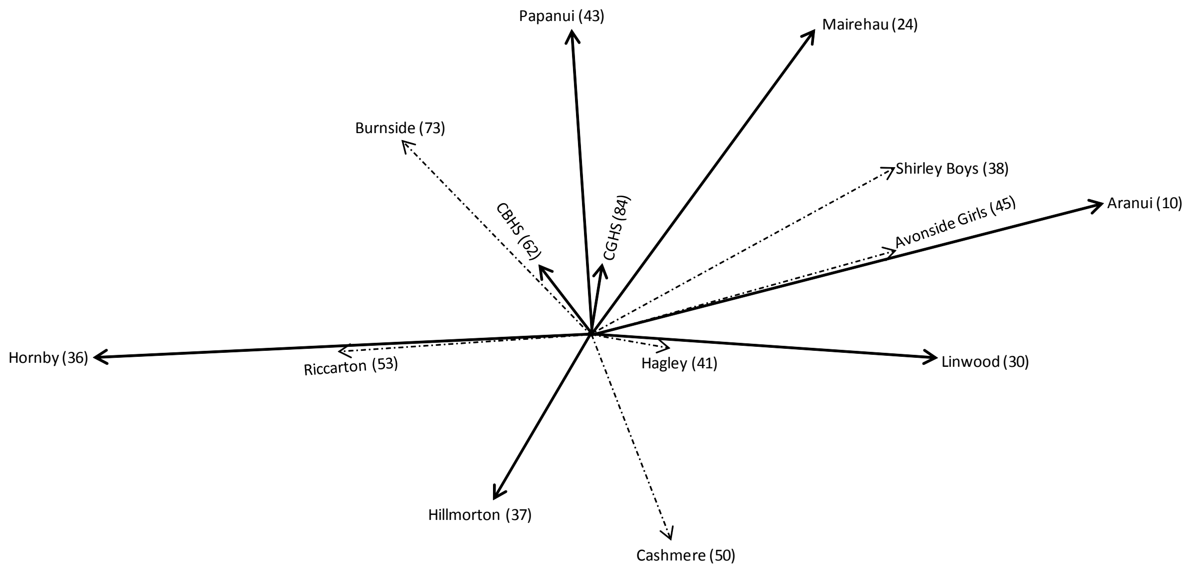


Figure 2b: Schooling Opportunity Set
for a Dwelling Inside the CGHS and CBHS Attendance Boundaries



Notes: Length and direction of arrows are proportional to actual distances. Solid lines are for schools that can be attended, broken lines are for schools whose enrolment zone excludes the particular dwelling.
Values in ( ) are NCEA Level 3 pass rates for each school in 2005.

4 Notice that for this particular dwelling the three closest schools are Hagley (1.3km), Girls High (1.9km) and Boys High (2.0 km) but it is outside the attendance boundaries for all of these schools.

We could use a model where simulated attendance is always at the closest school one is allowed to attend, but that enforces behaviour akin to what school zone proponents demand by creating exclusive local catchment areas. Moreover, four of the 14 schools are single-sex and we have no data on the gender of residents so tying a dwelling to a particular school is not very realistic. Instead, being informed by Tobler's first law of geography,[5] we calculate a weighted average where the weights are the (normalized) inverse of the distance from the dwelling to each school in the opportunity set. In other words, closer schools are more important in the schooling opportunity set for a particular dwelling. Specifically, for the dwelling in Figure 2a, the inverse distances to the six available schools add up to 1.29, so we calculate:

$$\begin{aligned} SOS^{Level\ 3} &= (1/2.20)/1.29 \times P^{Hill} + (1/4.84)/1.29 \times P^{Lin} + (1/5.42)/1.29 \times P^{Pap} \\ &\quad + (1/6.30)/1.29 \times P^{Mai} + (1/6.63)/1.29 \times P^{Horn} + (1/7.59)/1.29 \times P^{Aran} \end{aligned}$$

where P^{School} is the Level 3 NCEA pass rate for the school whose abbreviated name is in the superscript, the values in ( ) are the inverse distances with the schools arrayed from nearest to furthest away and the denominator of 1.29 is a normalization so that the weights add to 1.0. For the dwelling in Figure 2a, the (inverse-distance) weighted average NCEA pass rate for the schools that a student from that dwelling is eligible to attend is 32.3%.

The dwelling in Figure 2b is just 750 meters from the dwelling in Figure 2a, but is inside the attendance boundaries of both Girls High and Boys High, which have the highest and third highest NCEA pass rates amongst the state secondary schools in the city. Therefore, the schooling opportunity set here is much better, with an (inverse-distance) weighted average NCEA pass rate for schools that a student living in this house may attend of 55.4%. It is this (inverse-distance) weighted average NCEA pass rate that we relate to house sales prices, controlling for dwelling attributes, neighborhood characteristics and geographic accessibility to a wide range of services. Our modeling approach is agnostic as to whether students in a particular dwelling actually attend a particular school, and simply summarizes their available options using a plausible model of human behavior, that nearby options should have a higher weight than more distant options.

A partial equilibrium approach to modeling reform is to recalculate schooling opportunity sets in the absence of the attendance boundaries. In other words, (inverse-distance) weighted averages of the NCEA pass rates for all 14 state secondary schools are calculated for each dwelling in the sample. For the dwelling in Figure 2a, this counterfactual schooling opportunity set has an average pass rate for NCEA Level 3 of 49.2% -- 17 percentage points higher than the (inverse-distance) weighted average pass rate of the six schools actually available given the attendance boundaries.

[5] Tobler (1970, p.236) is the first reference known to invoke the first law of geography: 'Everything is related to everything else, but near things are more related than distant things.'

The implication of attendance boundaries of 'locking kids out' (LaRocque 2005) is made very clear by this example. In contrast, for the dwelling in Figure 2b the counterfactual schooling opportunity set has a slightly lower average pass rate (51.9% versus 55.4%) because the only school previously unavailable and with a higher pass rate than the actual average for this dwelling (Burnside) is over four kilometers away and so does not much alter the weighted average for the counterfactual situation of no boundaries. Meanwhile a nearby school that was also previously unavailable (Hagley) has a low pass rate and so the net effect for this dwelling of opening up access to all state schools is to slightly reduce the weighted average pass rate of the schools that are available.

This simulated removal of attendance boundaries is only a partial equilibrium analysis because in the absence of an elastic supply response of popular schools to increased enrolments, some other form of rationing is likely to be imposed.[6] To the extent that other forms of rationing have some effect on overall property prices and on the attractiveness of particular dwellings (for example, because of changed traffic flows and commuting costs as enrolment patterns change) a more complete general equilibrium analysis would be needed. Nevertheless, the partial equilibrium approach is useful for better understanding the incidence of the attendance boundaries policy, since it can show which houses have prices that are higher or lower because of the variation in the schooling opportunities that they provide, and the sort of neighborhood characteristics for these houses that may be relevant to the political economy of reform.

IV. Econometric Specification and Results

We estimate the following model of the logarithm of dwelling sales prices (P) using Ordinary Least Squares (OLS) regression:

$$\ln P_i = \beta_0 + \beta_1 SOS_i^j + \sum_{d=1}^{D} \delta_d D_i^d + \sum_{c=1}^{C} \gamma_c D_i^c + \sum_{a=1}^{A} \eta_a D_i^a + \varepsilon_i$$

where SOS_i^j is the schooling opportunity set for dwelling i using proxy variable j, δ_d is a vector of coefficients on dwelling attributes, γ_c is a vector of coefficients on neighbourhood characteristics, η_a is a vector of coefficients on the geographic accessibility measures, and ε_i is the disturbance term. Four proxy variables for the schooling opportunity set are used – the pass rates in the NCEA examinations at Levels 1, 2 and 3 (corresponding typically to Year 11, 12 and 13 of school) and the average of these three pass rates.

[6] Thomson (2010) notes that government in New Zealand has not provided an institutional or resource framework that allows for the expansion of successful schools, making supply highly inelastic.

There are typically two concerns with interpreting $\hat{\beta}_1$ as the causal effect of school performance on house prices; reverse causation and omitted variable bias. A further concern is that OLS standard errors may be wrong if disturbances are spatially auto-correlated, where residuals for observation *i* are not independent of neighbouring residuals. Reverse causation may occur if schools are locally funded, because wealthier areas can pay for either more or better inputs that raise school performance, and since property is one of the main forms of wealth the effect could be from house prices to performance rather than the reverse. But in New Zealand state schools are fully funded from central government revenues, breaking any funding link between local wealth and school performance. In fact the funding formula slightly favors schools whose students come from economically disadvantaged families, so as to provide additional resources to support their learning needs. These disadvantaged families typically live in cheap (or rented) housing, so this funding mechanism further weakens any hypothesized effect of higher local house prices allowing more revenue for schools to use for improving performance.[7]

An omitted variable bias occurs if determinants of house prices not in the model are correlated with school performance. In other words, the schooling variables may act as a proxy for omitted characteristics, and so the $\hat{\beta}_1$ captures not just the effect of better schooling opportunities but also effects of other desirable attributes. The scope for omitted variable bias depends on the richness of the covariates that are included, and the current model includes an extensive set of variables that should proxy for unobserved geographical and neighborhood characteristics, which are the factors most likely to correlate with school performance.

Even if relevant but omitted characteristics are not correlated with the included school variables, there is concern about violating the OLS assumption that disturbances are independent. One could try to empirically estimate the correlation between the disturbance for dwelling *i* and all other disturbances but this is infeasible since there are $N \times N$ correlations to estimate, plus the β and σ^2 parameters of a standard regression model, exceeding the number of observations, *N*.

A *spatial weights matrix* is one way to reduce the dimensionality of the problem, by imposing some structure. Let there be an $N \times N$ matrix whose elements are $w_{ij} = 1/d_{ij}$ where d_{ij} is the distance between observations *i* and *j* (inverse distance weights); this matrix allows all interactions between the disturbance for dwelling *i* and all other disturbances to be parameterized in the form of a weighted average, with a parameter λ measuring the strength

[7] Specifically, schools are grouped into deciles based on socio-economic indicators (household income and crowding, education, income source and occupations) from Census data for their catchment area. For a secondary school with a roll of 1,000 students, a school in the lowest decile would get $980,000 of extra funding while an equivalently-sized top decile school would get $53,000, in addition to the usual salary and operating expenses that are paid for all state schools (Ministry of Education, 2014).

of this relationship (Anselin 1988). Specifically, we can estimate the *spatial error model* whose disturbances are decomposed into a spatially uncorrelated component, ν_i and the spatially correlated part: $\lambda \mathbf{w}_i \xi_i$, where $\mathbf{w}_i$ is the vector of spatial weights summarizing connections between location *i* and all *j* locations and ξ_i summarizes the disturbances in each of those locations.

The full results of the OLS and spatial error regressions are reported in Appendix Table 1. These models explain from 74.9% to 76.1% of the variation in house prices, and show very precisely estimated effects of schooling opportunity sets on prices. We focus here on the effects of the schooling variables, which use the (inverse-distance) weighted average NCEA pass rate for the schools that a student is eligible to attend to proxy for the schooling opportunity set of each dwelling. A one percentage point increase in the weighted average NCEA pass rate at Level 1 increases house prices by 0.7%, all else the same (Table 1). A one percentage point higher NCEA Level 2 or Level 3 pass rate is associated with houses prices that are 0.8% higher.

Table 1: Estimated Effects of School Performance on House Prices

	Level 1	Level 2	Level 3	Level 1-3 Mean
Regression coefficient	0.007	0.008	0.008	0.009
Robust *t*-statistic	(12.28)**	(14.86)**	(16.06)**	(15.23)**
Predicted values with baseline characteristics[a]				
Median house price	$275,830	$275,540	$274,860	$275,220
Mean house price	$308,870	$308,900	$308,920	$308,910
Predicted values with a 1 standard deviation increase in weighted average NCEA pass rates[a]				
Median house price	$290,160	$290,300	$294,700	$292,730
Mean house price	$324,910	$325,450	$331,230	$328,570
Impact of standard deviation increase in weighted average NCEA pass rates				
Median	$14,330	$14,760	$19,840	$17,510
Mean	$16,040	$16,550	$22,310	$19,660
As % of baseline value	5.2%	5.4%	7.2%	6.4%

Notes:

Full details of the regressions are in Appendix Table 1. ** is statistically significant at $p<0.01$ level.

[a] The predicted values in dollar terms are based on the Duan (1983) smearing estimate, since the underlying model is semi-logarithmic.

In order to put these effects into more comparable terms, we use the regressions to predict median and mean prices using the average characteristics of all dwellings and then re-predict the prices after a simulated standard deviation increase in NCEA pass rates (which corresponds to percentage point increases in pass rates of 7.3, 6.4 and 8.6 for NCEA Level 1 to Level 3). The predicted rise in house prices from these higher pass rates range from $14,300 to $19,900 at the median and from $16,000 to $22,300 at the mean (in 2005 dollars). As a percentage of predicted baseline house prices, these are increases of 5.2%, 5.4% and 7.2% for standard deviation increases in NCEA pass rates at Level 1 to Level 3 (Table 1). Since the results are similar across the different NCEA levels, to simplify the rest of the discussion the schooling opportunity set for each dwelling is summarized by the average of the Level 1 to Level 3 pass rates. A standard deviation increase in this average is capitalized into house prices that are 6.4% higher.

To assess the robustness of the results, we consider three alternative specifications, in columns (5) to (7) of Appendix Table 1. First, we include a variable that counts the number of school attendance boundaries that a dwelling lies in (which ranges from zero to four). One may think that the property market values an increase in options, but this added variable is statistically insignificant and hardly alters the coefficient on the average NCEA pass rate. We then add dummy variables for each school zone that a property lies in, and while four of the dummies for particular schools are statistically significant (and as a set all eight are jointly significant) their inclusion hardly alters the coefficient on the average NCEA pass rate. Based on these results, we do not believe that omitted variable bias is causing us to find that a standard deviation increase in the average NCEA pass rate is capitalized into house prices that are 6.4% higher.

Finally we consider whether allowing for spatial autocorrelation changes the results, using a spatial error model where the weights matrix is based on inverse distances between dwellings *i* and *j*.[8] The results in column (7) of Appendix Table 1 show no change in the coefficient on the NCEA pass rate, compared with the OLS results in column (4). While the OLS assumption of independent errors is violated, with a highly significant coefficient of $\lambda=0.99$ on the spatially lagged residuals, accounting for this does not change the inferences about school performance, with the weighted average NCEA pass rate still highly statistically significant ($t=16.5$).

While the control variables are included in the model to ensure that there is no omitted variable bias, we briefly summarize the patterns they reveal. All else the same, there is a location premium for being closer to primary schools, food outlets, and some health providers (General Practitioner, accident and emergency facility, ambulance service) and being further from sports and leisure facilities, fire stations, pharmacies and secondary schools. Meshblocks with higher shares of ethnic minorities, of adults with no qualifications, home owners, full time workers, and with more crime and more unequally distributed incomes have lower house prices; higher prices are in meshblocks with higher household incomes, and higher shares of the foreign born and of the tertiary educated. Dwelling prices fall with age and rise with floor area (both at a diminishing rate), are higher for more land area especially

[8] This is estimated using the *Stata* maximum likelihood SPMLREG routine provided by Jeanty (2010).

in the inner suburbs, and are higher for having a good view, a deck, more car parking, internal garaging, being in good condition and being rated by the valuation agency as of superior quality.

V. Implications

There are at least three implications for policy from the results presented in Section IV. First, the extent of 'selection by mortgage' into better performing New Zealand schools is substantial and may exceed what is seen in other countries. For example, house prices in the Australian Capital Territory rise 3.5% for each standard deviation increase in median Year 12 test scores of the high school whose attendance boundary they are in (Davidoff and Leigh 2008). Using a similar method but focusing on primary schools, Gibbons, Machin and Silva (2013) find a price premium for a standard deviation increase in test scores of about three percent in England.

Machin (2011) summarizes ten different studies that use a variety of methods and look at different schooling levels in four countries; the median estimate is that house prices rise by four percent for a standard deviation increase in school performance. Only two of the ten estimates are larger than what is found in the current study, so it is reasonable to conclude that selection by mortgage is more important in New Zealand than in many other places, possibly because centrally-funded but self-managing (including boundary-setting) public schools have a dominant position in the New Zealand education market. In other settings, parents may have more options to use parochial or private schooling or may be able to sort across communities that locally fund schools. Absent those options, the property market in New Zealand becomes one of the main selection mechanisms open to parents who are ambitious for their children.

Such selection by mortgage can be expected to reduce social mobility across generations, since it is the children of rich parents who are most likely to attend the best performing of the publicly funded schools, given that the barrier to entry is the price that one is willing to pay for a house. Moreover, since the most academically able students are not necessarily matched with the best performing schools, there are likely to be inefficient outcomes of the human capital investment process. These inefficiencies could potentially be avoided by using other selection criteria such as entrance examinations, or if the concern was with equitable outcomes a random lottery could be used to ration places into better performing schools. Alternatively, a voucher scheme could be introduced so that parents could purchase education from competing providers, with examples of such schemes in Chile (Hsieh and Urquiola 2006) and Florida (Figlio and Hart 2014) and a proposed scheme that was voted down in California (Brunner and Sonstelie 2003).

There is likely to be a strong ethnic component to social immobility induced by selection by mortgage. International comparisons of student achievement, such as the OECD's Programme for International Student Assessment (PISA), show that New Zealand ranks highly, on average, in terms of 15-year olds' test scores for reading, mathematics and science. But New Zealand also has one of the longest tails of poor performers (along with Australia and the Netherlands) with Maori and Pacific students over-represented at the bottom end (OECD, 2013).

In other countries it has been found that some or even all of the racial gaps in test scores can be eliminated when under-performing ethnic minorities (such as blacks in the U.S.) attend high quality schools (Rothwell 2012). Maori and Pacific Island students are unlikely to attend high quality schools when there is selection by mortgage, since these two ethnic groups have the lowest net worth (including dwelling wealth) of any groups in New Zealand (Scobie, Gibson and Le 2005). Indeed, during the 1990-98 period when school attendance boundaries were abolished these two ethnic groups responded more than did the majority European/Pakeha ethnic group, by attending schools outside the previous boundaries (LaRocque 2005).

The second implication of the econometric results is that improvements in school quality appear to be very highly valued by New Zealand households. According to Reserve Bank statistics, the total value of housing in New Zealand (in 2012) is $655 billion.[9] The econometric results suggest that a standard deviation increase in school quality, as measured by the pass rates in NCEA examinations, is associated with house prices that are 5-7 percentage points higher, all else the same. Consider then the effect of interventions like heightened school competition, higher remuneration and performance pay for teachers and so forth, which for the sake of argument are assumed here to have the effect of raising NCEA pass rates across the board by one standard deviation. The capitalized value in the residential property market from this hypothetical increase in school quality would be approximately $42 billion.

The New Zealand government recently announced an initiative to create new teaching and school leadership roles aimed at raising student achievement levels.[10] The main components are the creation of 'expert teacher' and 'lead teacher' roles that provide financial allowances to teachers who demonstrably lift student achievement and who can act as role models for teachers elsewhere. This package of reforms is budgeted to cost just $360 million over four years (and just $150 million in the most expensive year). Compared with the apparent valuation of school quality revealed by the willingness to pay more for dwellings that provide a better schooling opportunity set, the extra expenditures to raise school quality seem small indeed.

The third implication of the results concerns the difficulty of reforming school attendance boundaries. The partial equilibrium effect of abolishing attendance boundaries is

[9] Available at: http://www.rbnz.govt.nz/statistics/tables/c18/

[10] Details are available at: http://www.beehive.govt.nz/sites/all/files/FAQs%20_0.pdf

for predicted prices of most properties to rise.[11] The reason is that abolishing boundaries enhances the schooling opportunity set for most dwellings (as in the example in Figure 2a) and this is highly valued in the property market.[12] However there are some properties with desirable locations under the current attendance boundaries that would not offer guaranteed enrolment in these high-performing secondary schools in the absence of boundaries (as in the example in Figure 2b). For this group of properties, the predicted price falls and the owners of such properties are likely to oppose reform of attendance boundaries. Indeed, evidence from voting patterns on a school voucher reform in California confirms this prediction; those who owned homes in neighborhoods with good public schools were more likely to vote against the voucher than those who lived in neighborhoods with inferior public schools (Brunner and Sonstelie 2003).

To examine how large this effect might be, we recalculated the schooling opportunity set for each dwelling in the absence of attendance boundaries, and used these counterfactual data to predict house prices using coefficients from the model in Column 4 of Appendix Table 1, based on average Level 1-3 NCEA pass rates. This simulated change sees dwellers of average houses facing a 10 percentage point higher average NCEA pass rate than for the schools accessible with attendance boundaries in place, and this change is valued in the property market at about $25,000 per house. In other words, a large share of the population is denied access to a valued service (high performing state secondary schools) based on where they live so removing restrictions adds value to the locations where they live. The simulated change in value for each house was then regressed on dummy variables for each school whose attendance boundary the dwelling is within (with those outside all boundaries the reference group). This regression showed houses inside the boundaries of two schools – Burnside and Christchurch Girls High School – would, all else the same, have predicted prices that are at least $20,000 lower than they would be with a continuation of the existing attendance boundaries.

Table 2 contains a comparison of these two school zones with the rest of Christchurch, in terms of population characteristics that are potentially relevant to the politics of reform. The two school attendance zones where prices are predicted to fall the most have higher income residents whose houses sell for almost 60% more than houses elsewhere. These residents also have much higher levels of education, with almost one-fifth of adults having a degree or higher qualification and only one-seventh having no qualifications, whereas elsewhere the

[11] An analysis of the weakening of school district boundaries and the adoption of open enrolment in Minnesota shows that while house prices rise in some areas and fall in others, overall, average prices rise, which provides some approximate evidence on the positive aggregate welfare gain (Reback 2005).

[12] Most media commentary in New Zealand is that school zones inflate house prices (for example, *National Business Review* 'Removing school zones scores double-win' March 7, 2014, p.37). This commentary focuses only on the houses made more expensive by the access they offer to popular schools, not on the overall effects of restricting access to a valuable public service that reduces value for many more houses.

unqualified group is more than twice as large as the degree-holding group. These highly educated and relatively rich residents with the Burnside and CGHS attendance zones are likely to be effective opponents of any proposed reforms of school attendance boundaries. In contrast, the beneficiaries of open-enrolment have characteristics that are less associated with political success and also face the problem that the gains are likely to be uncertain at the individual level since some other rationing device, such as a lottery, may be needed to prevent over-crowding of high-performing schools.

Table 2: Characteristics of Neighborhoods Where House Prices Are Predicted to Fall the Most if School Attendance Boundaries were Removed

	Burnside & CGHS	Rest of Christchurch
Median household income (in 1995 prices)	\$50,530	\$42,510
Average sales price of houses (2004-05)	\$456,940	\$291,820
Percent with degree or higher qualification (age 15+)	19.1%	11.1%
Percent with no educational qualifications (age 15+)	13.6%	23.3%

Notes
Based on author's calculation using the model in column (4) of Appendix Table 1 to create counterfactual house prices (assuming no school attendance boundaries) which are regressed on dummy variables to identify zones with the largest price falls. The characteristics are calculated from meshblock averages from the 2006 Census.

VI. Conclusions

The effect of school performance on house prices in Christchurch, New Zealand has been examined in this study. A standard deviation increase in performance, as measured by pass rates in NCEA examinations, raises house prices by 6.4%, all else the same. This is a larger response than is typical of other countries, perhaps due to special features of schools in New Zealand such as their ability to set their own attendance boundaries and the absence of locally-funded schools that aid sorting across communities. Hence, the property market becomes the main schooling selection mechanism for New Zealand parents who are ambitious for their children. Even though schools may nominally be 'free', students from poorer households face more restricted schooling opportunities than do wealthier students, being constrained through the housing market.

Almost two decades have passed since New Zealand's brief experiment with relaxing school attendance boundaries in the 1990s. The frequency of reselling houses makes it likely that most home-owners have paid a price for their dwelling that includes the expected value of access (or exclusion) from particular schools. Consequently there will be windfall gains and losses if future policy reform allows a weakening of attendance boundaries and an opening up of school enrolments. Nevertheless, the wide variation in school performance and the contribution of attendance boundaries to reducing social mobility suggests even difficult reform is worthwhile.

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Appendix

Table 1: OLS and Spatial Error Regression Models of House Prices in Christchurch

	------Ordinary Least Squares------						Spatial Error
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
NCEA Level 1 Pass Rate	0.007						
	(12.28)**						
NCEA Level 2 Pass Rate		0.008					
		(14.86)**					
NCEA Level 3 Pass Rate			0.008				
			(16.06)**				
Average NCEA Pass Rate				0.009	0.008	0.007	0.009
				(15.23)**	(10.24)**	(6.86)**	(16.50)**
# of schools zones located in					0.006	0.087	
					(0.94)	(2.58)**	
Dwelling attributes							
Dwelling age	-0.055	-0.057	-0.057	-0.057	-0.057	-0.060	-0.058
	(13.68)**	(14.18)**	(14.33)**	(14.23)**	(14.16)**	(14.91)**	(16.61)**
Dwelling age squared	0.437	0.455	0.455	0.454	0.452	0.479	0.458
	(11.70)**	(12.17)**	(12.28)**	(12.19)**	(12.10)**	(12.96)**	(14.28)**
Dwelling floor area	0.443	0.444	0.446	0.445	0.445	0.446	0.438
	(14.88)**	(15.06)**	(15.11)**	(15.07)**	(15.06)**	(15.13)**	(30.54)**
Dwelling floor area squared	-0.047	-0.047	-0.047	-0.047	-0.047	-0.048	-0.046
	(5.88)**	(6.04)**	(6.03)**	(6.02)**	(6.02)**	(6.05)**	(14.32)**
Land area of section (lot)	0.122	0.134	0.119	0.126	0.126	0.102	0.121
	(8.90)**	(9.75)**	(8.76)**	(9.23)**	(9.24)**	(7.08)**	(13.44)**
Section area × outer ward	-0.079	-0.094	-0.074	-0.084	-0.084	-0.047	-0.073
	(7.43)**	(8.74)**	(7.14)**	(7.96)**	(7.96)**	(3.80)**	(7.98)**
Dwelling has a good view	0.086	0.088	0.088	0.089	0.088	0.103	0.092
	(7.14)**	(7.41)**	(7.44)**	(7.49)**	(7.45)**	(8.67)**	(9.52)**
Number of carparks	0.025	0.025	0.025	0.025	0.025	0.025	0.025
	(11.88)**	(11.98)**	(12.04)**	(11.99)**	(11.99)**	(12.09)**	(14.09)**
Dwelling has internal garage	0.078	0.078	0.079	0.079	0.079	0.076	0.076
	(5.27)**	(5.22)**	(5.26)**	(5.24)**	(5.25)**	(5.20)**	(8.11)**
Dwelling has a deck	0.022	0.021	0.023	0.022	0.022	0.023	0.022
	(4.93)**	(4.77)**	(5.27)**	(4.97)**	(4.97)**	(5.39)**	(5.00)**

	Ordinary Least Squares						Spatial Error
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rated as poor quality	-0.067	-0.066	-0.071	-0.068	-0.068	-0.073	-0.068
	(4.21)**	(4.17)**	(4.42)**	(4.31)**	(4.31)**	(4.59)**	(4.79)**
Rated as superior quality	0.122	0.118	0.115	0.117	0.117	0.106	0.112
	(10.94)**	(10.64)**	(10.43)**	(10.56)**	(10.55)**	(9.81)**	(12.29)**
Wall/roof in good condition	0.021	0.021	0.017	0.020	0.020	0.014	0.018
	(3.79)**	(3.77)**	(3.14)**	(3.53)**	(3.58)**	(2.52)*	(3.26)**
Meshblock attributes							
Minority ethnic group %	-0.398	-0.401	-0.379	-0.390	-0.390	-0.374	-0.341
	(10.85)**	(11.02)**	(10.31)**	(10.66)**	(10.66)**	(10.19)**	(9.46)**
Foreign born %	0.108	0.104	0.063	0.079	0.082	0.119	0.072
	(2.35)*	(2.31)*	(1.36)	(1.72)+	(1.77)+	(2.60)**	(1.74)+
Degree or higher %	0.547	0.527	0.490	0.511	0.512	0.461	0.441
	(10.01)**	(9.72)**	(9.02)**	(9.42)**	(9.43)**	(8.60)**	(8.49)**
No school qualification %	-0.153	-0.146	-0.171	-0.143	-0.142	-0.217	-0.144
	(3.79)**	(3.66)**	(4.37)**	(3.59)**	(3.58)**	(5.40)**	(3.54)**
Gini - personal income	-0.200	-0.195	-0.183	-0.204	-0.205	-0.105	-0.159
	(1.96)+	(1.92)+	(1.81)+	(2.02)*	(2.02)*	(1.04)	(1.71)+
Median household income	0.039	0.037	0.036	0.037	0.037	0.026	0.034
	(13.56)**	(12.89)**	(12.83)**	(13.12)**	(13.12)**	(8.72)**	(13.02)**
Crime rate	-0.164	-0.186	-0.175	-0.169	-0.172	-0.177	-0.171
	(3.96)**	(4.50)**	(4.25)**	(4.09)**	(4.20)**	(3.91)**	(3.87)**
Fulltime employed %	-0.313	-0.280	-0.283	-0.278	-0.278	-0.240	-0.258
	(8.75)**	(7.80)**	(8.02)**	(7.81)**	(7.80)**	(6.66)**	(7.81)**
Unemployed %	-0.185	-0.168	-0.148	-0.155	-0.158	-0.106	-0.149
	(1.77)+	(1.62)	(1.44)	(1.50)	(1.53)	(1.05)	(1.44)
Home owner %	-0.108	-0.109	-0.090	-0.099	-0.099	-0.052	-0.073
	(5.33)**	(5.46)**	(4.46)**	(4.95)**	(4.93)**	(2.65)**	(3.69)**
Distance to nearest:							
Sport and leisure facility	0.014	0.015	0.015	0.015	0.015	0.011	0.016
	(8.74)**	(9.25)**	(9.46)**	(9.17)**	(8.61)**	(6.42)**	(8.71)**
Fire station	0.004	0.003	0.007	0.005	0.004	0.002	0.005
	(3.56)**	(2.60)**	(5.65)**	(3.96)**	(3.62)**	(1.31)	(3.41)**

	--------Ordinary Least Squares--------						Spatial Error
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ambulance service	-0.010	-0.008	-0.013	-0.010	-0.010	-0.007	-0.011
	(7.94)**	(6.05)**	(10.14)**	(7.68)**	(7.28)**	(5.14)**	(7.23)**
Secondary school	0.023	0.021	0.023	0.022	0.022	0.018	0.023
	(11.93)**	(11.00)**	(12.00)**	(11.52)**	(11.49)**	(9.51)**	(11.76)**
Supermarket	0.003	0.002	0.004	0.003	0.003	0.004	0.002
	(1.57)	(0.79)	(2.04)*	(1.70)+	(1.73)+	(1.91)+	(1.05)
Accident & emergency facility	-0.003	-0.003	-0.003	-0.003	-0.003	0.001	-0.004
	(2.52)*	(2.30)*	(2.46)*	(2.31)*	(2.14)*	(0.61)	(2.69)**
General Practitioner	-0.013	-0.013	-0.011	-0.012	-0.012	-0.007	-0.011
	(3.44)**	(3.51)**	(3.01)**	(3.33)**	(3.30)**	(1.86)+	(2.55)*
Pharmacy	0.012	0.011	0.010	0.011	0.011	0.005	0.009
	(2.73)**	(2.57)*	(2.29)*	(2.51)*	(2.50)*	(1.12)	(2.00)*
Food establishment	-0.014	-0.012	-0.013	-0.013	-0.013	-0.006	-0.011
	(4.10)**	(3.56)**	(3.94)**	(3.94)**	(3.87)**	(1.91)+	(2.96)**
Beach	0.000	0.002	-0.003	-0.001	-0.001	-0.000	-0.000
	(0.18)	(2.46)*	(3.46)**	(1.17)	(1.08)	(0.04)	(0.04)
Primary school	-0.017	-0.017	-0.017	-0.017	-0.017	-0.017	-0.016
	(6.28)**	(6.22)**	(6.47)**	(6.46)**	(6.48)**	(6.44)**	(5.29)**
Park or playground	-0.002	-0.003	-0.004	-0.003	-0.003	-0.004	-0.005
	(0.68)	(0.98)	(1.32)	(1.09)	(1.01)	(1.32)	(1.34)
Temporal indicators:							
Quarter 2	0.053	0.053	0.053	0.053	0.053	0.055	0.054
	(9.10)**	(9.13)**	(9.16)**	(9.14)**	(9.15)**	(9.69)**	(9.67)**
Quarter 3	0.079	0.080	0.080	0.080	0.080	0.082	0.081
	(12.21)**	(12.34)**	(12.38)**	(12.35)**	(12.35)**	(12.91)**	(13.52)**
Quarter 4	0.073	0.073	0.073	0.073	0.073	0.075	0.074
	(11.56)**	(11.66)**	(11.65)**	(11.65)**	(11.64)**	(12.14)**	(12.45)**
Constant	11.734	11.621	11.831	11.686	11.702	11.722	11.766
	(222.67)**	(215.79)**	(246.10)**	(227.63)**	(215.31)**	(196.43)**	(36.03)**
Dummies for each school zone	No	No	No	No	No	Yes	No
R^2	0.749	0.752	0.753	0.752	0.752	0.761	[a]

Notes: Robust *t*-statistics in parentheses, + significant at 10%; * significant at 5%; ** significant at 1%. [a] There is no R^2 defined for the spatial error model, but the squared correlation between the predicted values and actual values is 0.752. In the spatial error model the coefficient on the spatially lagged residuals (λ) is 0.99 with a *t*-statistic of 145.