2015 Hawaii University International Conferences
Arts, Humanities, Social Sciences & Education
January 03 - 06, 2015
Ala Moana Hotel, Honolulu, Hawaii

Analysis of the Impact of the Closure of a Laboratory School on House Prices

Isakson, Hans & et al
University of Northern Iowa

Dr. Hans Isakson
Ms. Alicia Rosburg
Department of Economics

Dr. Mark Ecker
Department of Mathematics

Dr. Tim Strauss
Department of Geography

University of Northern Iowa

Analysis of the Impact of the Closure of a Laboratory School on House Prices

Synopsis:

This study examines the impact of the sudden closure of a public laboratory school on nearby house prices. The study uses a difference-in-difference approach with spatial effects in an hedonic model. It compares house prices in the attendance zone of the closed school (a treatment group) with house prices in a comparable, adjacent neighborhood (a control group), before and after the closure. We find that the closure reduced house prices in the attendance zone by about 5 to 10 percent.

Analysis of the Impact of the Closure of a Laboratory School on House Prices

Abstract

This paper examines the impact of the sudden closure of a public laboratory school on nearby house prices in Cedar Falls, Iowa in 2012. Residents in the school's attendance zone had their choice of where their children could attend school: the city schools or the laboratory school. The appeal of living in the school's attendance zone was often highlighted in real estate listings. We use a difference-in-difference (DiD) model to estimate the effect on house prices associated with the sudden closure of the school. We find that house prices in the attendance zone declined by 6.8% (about $9000 for the mean house price) after the closure.

Key Words: difference-in-difference, education, hedonics, house sales, school closure, spatial econometrics

1. Introduction

Malcolm Price Laboratory School (MPLS), the laboratory school at the University of Northern Iowa (UNI) in Cedar Falls, Iowa, was established in 1914.[1] In 1945, the state approved funding for the construction of a new building to house the laboratory school and other facilities. After postwar delays, the university purchased land for the school in the fall of 1948. Construction of the school began in the fall of 1950, and the first building (an elementary school) was completed in the summer of 1953. A high school building was completed in the fall of 1955. An attendance zone was established that overlapped the Cedar Falls Public School District such that households located within the attendance zone had a choice to send their children to either MPLS or the designated Cedar Falls public school.

Throughout its history, the school had two major objectives. First, to provide the best education possible to students attending the school. Second, to provide a world-class laboratory experience, in which teaching innovations were implemented and evaluated, and where teachers in training could practice their trade under the watchful eye of master teachers. Over time, MPLS gained the reputation of providing a high-quality education with small classes and multiple instructors in each classroom.

Previous attempts were made to close MPLS in 1971, 1986, 1989, and 2002. These attempts were derailed, in part, by the efforts of parents and alumni to keep it open. On February 16, 2012, UNI President Ben Allen sent an email to university employees stating that several programs, including MPLS, were under review for possible cuts. The next day, the local newspaper reported, based on an interview with Allen, that “specific details about those cuts, consolidations or closures have yet to be finalized” (Ericson, 2012b). Allen cited several issues regarding MPLS, including budget considerations, the cost of renovating or completely replacing

[1] Information about the history of Malcom Price Laboratory School is from Peterson et al. (2012).

the building, and the idea of moving to a "virtual model" of teacher education. Six days later (February 22), Allen announced to teachers, parents, and students that MPLS would be closed at the end of the academic year, pending approval of the Iowa Board of Regents. Five days later (February 27), the Regents met by telephone to approve Allen's recommendation; Iowa Governor Terry Branstad expressed his support for the decision the next day. In a matter of twelve days, the school went from a business-as-usual routine to the reality of closure in a few months. Parents were notified that initial decisions regarding the enrollment of students at surrounding schools for the following fall would need to be made by April 16. The process of demolition began after the school year ended (summer 2012). Rarely does one witness such a quick decision by a public board with such a geographically targeted impact.[2]

While the school operated, students within the MPLS attendance zone had priority and were guaranteed enrollment at the school; they also had the option of attending a Cedar Falls public school. Students living outside the MPLS zone were allowed to enroll subject to available space and with the possible payment of tuition.[3] In other words, prior to its closure, households within the MPLS attendance zone owned an option that households outside the zone did not own. Because options have value (Bennett et al., 2001; Deng et al., 2000; Quigg, 1993), the sudden removal of this option is expected to reduce the value of houses within the attendance zone. Further, anecdotal evidence suggests that housing decisions prior to the school's closure were influenced by the appeal of MPLS and residence within its attendance zone. For example, some parents moved into the attendance zone so that their children could attend the school (Linh,

[2] The National Clearinghouse for Educational Facilities (McMilin, 2010, pg 2) recommends that "a decision to close a school should be made as early as possible in the school year, but no later than December."
[3] Some school districts allowed their students to enroll freely in MPLS, while others did not. Students residing in the Cedar Falls Public School District were required to pay tuition to attend MPLS.

2013), and in one high-profile case, several parents were caught falsely claiming their children lived within the MPLS zone to ensure their attendance and avoid paying tuition (Reinitz, 2010).

Consequently, residents within the zone justifiably felt that the values of their homes were enhanced by the guaranteed access to MPLS. This perception was reinforced by the mention of location within the MPLS zone as a selling point in real estate listings. After the closure announcement was made, residents expressed concerns about the impact on property values and more generally the neighborhood's character. The President of the Waterloo-Cedar Falls Board of Realtors similarly suggested that MPLS had increased area property values but by an uncertain amount that would be difficult to measure (Ericson, 2012a).

Whether or not house values inside the attendance zone were enhanced by the school is the empirical question addressed in this study. The sudden decision and actual closure of the school creates a quasi-experimental opportunity in which house prices before and after the closure, as well as inside and outside the attendance zone, can be examined for evidence of a positive external effect associated with the school, holding other things that affect housing prices constant. The purpose of this study is to understand the effect on housing prices, if any, that might be associated with the school's sudden closure. To our knowledge, this is the first study (see section 2) to analyze the housing market effects of a laboratory school. Further, the MPLS closure differs from most school closings analyzed in the literature in that under-performance and/or declining enrollment did not contribute to its closure.

2. Literature Review

The value of schools has been studied extensively across many fields. In economics, the common approach is to use a hedonic model to evaluate the relationship between housing values and school quality.[4] A consistent finding in the hedonics literature is that housing values are higher in areas with higher school quality; this relationship emerges from studies spanning several countries, modeling techniques, and levels of education (Black, 1999; Black and Machin, 2011; Brasington, 1999; Clapp et al., 2008; Dhar and Ross, 2012; Downes and Zabel, 2002; Figlio and Lucas, 2004; Gibbons et al., 2013; Kane et al., 2006; Machin, 2011). The general conclusion of these studies is that parents are willing to pay a premium, and sometimes a substantial premium, for access to better performing schools (Black and Machin, 2011; Machin 2011). The premium, however, tends to be lower when estimated using more complex empirical approaches (e.g., boundary approaches, neighborhood fixed effects, difference-in-differences approaches) than standard OLS regressions (Black and Machin, 2011; Clapp et al., 2008; Dhar and Ross, 2012; Kane et al., 2006).[5]

A portion of the hedonics literature has focused more specifically on which measures of school quality are valued by homeowners (Brasington, 1999; Brasington and Haurin, 2006; Downes and Zabel, 2002; Gibbons et al., 2013; Gibbons and Silva, 2008; Hayes and Taylor, 1996). A majority of the literature suggests that homeowners value high test scores, and therefore test scores are the most commonly used proxy for school quality in hedonic models. Alternative measures such as value-added or subjective measures (e.g., parent satisfaction, child happiness) have gained popularity in recent years, but the evidence has been mixed as to whether these measures are capitalized into housing values (Brasington and Haurin, 2006; Gibbons et al., 2013).

[4] The hedonic method is the use of statistical techniques on housing prices to determine the implicit price of housing characteristics, including school quality (Rosen, 1974).
[5] For a relatively comprehensive overview of the hedonics literature on housing values and school performance see Black and Machin (2011).

The subset of literature most relevant to our analysis includes the studies on quasi-experimental situations within educational settings. Such quasi-experimental situations may arise for a variety of reasons – changes in education policy, attendance rezoning, school closings and openings, consolidations, etc. The rarity under which these situations occur and, when they do, the availability of sufficient data has limited the number of empirical studies on this topic. However, a few key findings within this literature are relevant to our study. Ries and Somerville (2004) analyze the housing market effects of school quality changes induced by attendance rezoning in Vancouver. The authors found negative effects but only for houses likely to be purchased by upper-income families. Jinnai (2011) uses the introduction of charter schools in North Carolina to evaluate if charter schools create spillover effects on traditional public schools. Jinnai finds evidence that public schools reallocate their resources to improve school quality in the presence of increased competition from charter schools. Burdick-Will et al. (2013) evaluate which factors influenced the closing and opening of elementary schools in Chicago during the late 1990s and 2000s. Schools in disadvantaged neighborhoods had a higher probability of closure, but only because they under-performed or were under-enrolled. Schools were more likely to open in neighborhoods that demonstrated socioeconomic revitalization and neighborhoods that had a declining proportion of white residents. The study most similar to ours is Bogart and Cromwell (2000) who evaluate housing market effects in an Ohio school district that reduced the number of elementary schools from nine to six; the school closures also resulted in changes in school racial composition (due to redistricting) and the introduction of a bus transportation system. The school closures and subsequent attendance rezoning resulted in significant losses in house values (9.9%).

According to the National Clearinghouse for Educational Facilities (McMilin, 2010), recent school closings have been driven by three main factors: enrollment decreases, economic downturn and budget deficits, and school choice. As mentioned above, most school closings in Chicago during the late 1990s and 2000s were a result of under-performance and under-enrollment (Burdick-Will et al., 2003). Sell and Leistritz (1997) identify a combination of factors (declining enrollments, declining federal support, and costs of accreditation and compliance) that contributed to several school consolidations in the early 1990s in North Dakota. MPLS differs from most school closings in that under-performance and/or declining enrollment did not contribute to its closure; the closing of MPLS was driven largely by exogenous changes in state funding and university budgeting decisions.

Hedonic price theory suggests that, all things equal, housing values in the MPLS attendance zone should decrease if the school's closure removed benefits to residents for which there is no close substitute. MPLS had a reputation of providing a quality education that was substantiated by standardized test scores and ACT scores.[6] The Cedar Falls public school system, however, also has a strong record of student achievement. Based on fourth grade test scores (a common metric for school quality), there was no statistical difference between MPLS and the Cedar Falls public elementary schools that overlapped the MPLS attendance zone.[7] With little variation in school quality metrics between MPLS and the Cedar Falls public schools,

[6] For example, fourth grade proficiency rates in reading, math, and science averaged 79, 85, and 88 percent, respectively, between 2004 and 2011. The average ACT score over this same time period was 22.9 (state average was 22.2 and national average was 21).

[7] Pair-wise multiple comparisons failed to reject the hypothesis that test scores were equal at the 10% level for 2004 – 2011.

housing prices may not be responsive to measurable school quality differences and therefore the closure of MPLS (Black, 1999).[8]

MPLS, however, may have provided benefits to homeowners within the attendance zone that are not fully captured by standardized test scores. Elementary and secondary schools are frequently a center for community integration and a source of community identity and spirit (Sell and Leistritz, 1997). Schools serve as neighborhood anchors that provide social capital (Besser et al., 2008), reinforce neighborhood socioeconomic growth, and offer social and educational stability for students (Burdick-Will et al., 2013). Residents of the MPLS attendance zone often expressed their convictions that the school was a valuable part of the neighborhood, and many parents believed that the innovative teaching methods used at MPLS and access to UNI resources better prepared students for post-secondary education. Thus, households in the attendance zone seemed to have valued living there.

The key empirical question is whether such attitudes and beliefs about the value of MPLS were capitalized into housing values. The sudden closure of MPLS provides a quasi-experiment opportunity to examine this question. Given a rich data set of house sales before and after the closure, both inside and outside the attendance zone, we are able to examine what effects, if any, might be associated with the school and its sudden closure.

3. Study Design

The effect of the closure of the MPLS is examined using a standard *quasi*-experimental, difference-in-difference (DiD) approach. The Cedar Falls housing market is used as a pseudo-laboratory in which the quasi-experiment occurs. The DiD approach is a popular technique for examining the impact of an event on housing prices. Recent examples include the effects of new

[8] Although not testable with our dataset, it is possible that MPLS may have created competition (and therefore market pressure) for the Cedar Falls public schools which incentivized them to maintain a certain quality level (and vice versa); evidence of such an effect has been found in cities that opened charter schools (Jinnai, 2011).

transportation stations (Gibbons and Machin, 2005), new sports stadiums (Tu, 2005), subsidized housing (Schwartz et al., 2006), community gardens (Voicu and Been, 2008), aquatic invasive species (Horsch and Lewis, 2009), LUST sites (Zabel and Guignet, 2012), and wind energy facilities (Hoen et al., 2013). The DiD approach has also been extensively used in the valuation of school quality and performance through the housing market; Black and Machin (2011) provide a detailed overview of this literature.

To properly employ a pure DiD technique, one would need test and control groups consisting of the *same* members before and after some treatment. Members of the test group receive the treatment, while members of the control group receive a placebo. In the double-blind version, the researcher does not know which members receive a placebo, and the group members do not know if they receive a placebo. In the DiD technique used in many housing market studies, such as those cited above, the members of both groups are *not the same* before and after the treatment (event), because, typically, the same (identical) houses do not sell just before and again right after the event. Instead, researchers statistically control for differences in the characteristics of the houses before and after the event and within the test and control groups. We use this approach for our analysis of the housing sales in the MPLS attendance zone.

The treatment event of interest is the closure of MPLS, and houses located within the MPLS attendance zone constitute the test group. The control group consists of an adjacent neighborhood located in central Cedar Falls (CCF). This neighborhood was selected as the control group because it contains housing similar in terms of age and size to that found in the MPLS attendance zone.[9] The CCF neighborhood is defined using natural neighborhood boundaries; namely, three of the four boundaries (west, east, and north) are defined as main

[9] Section 5 provides summary statistics for the MPLS attendance zone, CCF neighborhood, and all Cedar Falls (Table 2).

roads passing through the city. The fourth boundary (south boundary) lies along the northern boundary of the MPLS attendance zone. For comparative purposes, the boundaries for the entire city of Cedar Falls, CCF, and MPLS are displayed in Figure 1 (along with housing sales and other points of interest). Figure 2 provides a zoomed in view of the MPLS attendance zone and CCF control group.

[Figure 1 and 2 about here]

4. Model

The model used in this study can be expressed in general terms as

$$Y_i = \alpha_1 MPLS_i + \alpha_2 After_i + \delta DiD_i + \beta X_i + \varepsilon_i, \qquad \text{for } i = 1,\dots,n \qquad (1)$$

where Y_i = log(price) for the i^{th} sale,

$MPLS_i$ = MPLS indicator variable for the i^{th} sale,

$After_i$ = Indicator variable for if the i^{th} sale is after the MPLS closure,

α_1 = parameter estimate of the marginal effect of being in the MPLS zone,

α_2 = parameter estimate of the marginal effect of time after the MPLS closure,

$DiD_i = MPLS_i \times After_i$, difference in difference interaction factor for the i^{th} sale,

δ = *DiD* parameter estimate,

X_i = vector of the independent variables for the i^{th} sale,

β = vector of sale specific parameters (including intercept) associated with the independent variables,

ε_i = error term associated with the i^{th} sale.

The dependent variable is the log of the sale price. To correct for inflation over time, we follow Bogart and Cromwell (2000) and deflate sale prices using a repeat-sales annual housing price index.[10] Housing price indexes for 2009 to 2013 are reported in Table 1.

[Table 1 about here]

To implement the difference-in-difference estimator, we create three indicator variables. The variable, *MPLS*, equals 1 if the house is in the MPLS attendance zone. The second variable, *After*, equals 1 if the house sold after April 1, 2012.[11] The third variable, *DiD*, is the difference-in-difference variable or the product of the first two indicator variables. The coefficient on the *DiD* variable (δ) is our estimate of the school closure effect and the focus of this study.

To control for differences among houses, we include a vector of independent variables (X) that would naturally be expected to influence house prices. Depending on our model specification, the independent variables or covariates include structural, neighborhood, and/or other characteristics (e.g., locational, temporal, and macroeconomic characteristics). A complete variable list and specific details of each variable are discussed in section 5.

To estimate the parameters of equation (1), we must include an error or disturbance term, ε. Standard Ordinary Least Squares (OLS) regressions assume that $\varepsilon \sim N(0, \gamma^2)$ where constant variance is assumed; γ^2 represents the constant variance parameter, after accounting for all values of the covariates. When dealing with spatial data, such as housing sales, the potential exists for the OLS parameter estimates to be biased, especially any spatial distance parameter estimates in the mean structure (e.g., distance to school). Visual examination of an empirical

[10] Repeat sales include houses in Cedar Falls with two sales transactions between January 1, 2006 and July 31, 2013 at least six months apart (to avoid "flips").
[11] While the MPLS closure was officially approved by the Board of Regents on February 27, 2014, we use a cutoff date of April 1, 2012 to allow for the lag in housing market transactions (i.e., closing period).

variogram (Cressie, 1993) of the OLS residuals in equation (1) reveals the presence of spatial correlations. Therefore, efforts to remove this source of bias will be incorporated into the model.

Spatial linear models assume that the errors are not independent; that is, two comparable houses that are closer in space sell for a more similar price than two comparable houses farther apart. For example, houses located near each other are also near the same neighborhood amenities and/or disamenities. In this case, the selling prices of nearby, comparable houses tend to be more correlated than comparable houses farther apart. We build spatial correlation into equation (1) by specifying the error term as follows:

$$\varepsilon \sim N(0, \tau^2 + \sigma^2) \tag{2}$$

where τ^2 is called the "nugget", i.e. a micro-scale or measurement error variability, in the geostatistical literature (Cressie, 1993). The sum $\tau^2 + \sigma^2$ in equation (2) is termed the spatial variability of the spatial process or "sill" (the variability of the house prices after adjusting for individual house characteristics). Finally, for two house sales with errors ε_i and ε_j, their spatial correlation is modeled as a function of their Euclidean distance apart, d_{ij}. Specifically, we adopt the spherical correlation structure, i.e.,

$$Corr(\ln(\epsilon_i), \ln(\epsilon_j)) = \tfrac{1}{2}\left(\phi^3 d_{ij}^3 - 3\phi d_{ij} + 2\right) \quad if\ d_{ij} \leq \tfrac{1}{\phi}. \tag{3}$$

The parameter ϕ directly controls the spatial correlation in the dataset and is termed the "range" (technically $\frac{1}{\phi}$ is the exact value of the range in equation (3) - see Ecker (2003) for the spherical correlation structure). Thus, any two houses that are separated by a distance of more than the range have selling prices that are essentially uncorrelated.

5. Data and Empirical Approach

The primary data for our analysis are housing sales that occurred in the MPLS attendance zone and CCF neighborhood between January 1, 2009 and July 31, 2013. The time frame analyzed was selected based on available data and to minimize any effects from previous closure attempts; the most recent closure attempt was in 2002. Further, the Iowa Legislature changed the designation of MPLS in 2008 to a 'statewide research and development school' (Iowa Code 256G). The intent of the legislation was to improve educational attainment, teacher preparation, and research on teaching practices. The law was expected to strengthen the school and improve its stature. To avoid capturing any effects from the change in designation, we limit our analysis to housing sales after January 1, 2009. In addition, the Cedar Falls housing market was not affected by the U.S. housing market decline that started in 2006. Rather, trend analysis suggests that the Cedar Falls housing prices actually increased over this period.[12]

Housing selling prices and characteristics for each house are obtained from the Black Hawk County Board of Supervisors.[13] These data include coordinates (State Plane Coordinate System, Iowa North, NAD 1983, in feet), which were used to generate points in a geographic information system for integrating spatial data, creating spatially-based variables, and analyzing results.[14] A supplemental data set from the City of Cedar Falls Fire Department was used to identify houses classified as rental properties. Table 2 lists the descriptive variables used for each transaction. Also reported in Table 2 are the variable means and standard deviations for all of Cedar Falls (N = 1881), for the CCF control neighborhood (N = 255), and for the MPLS

[12] As the largest employer (with multiple locations) in the Cedar Valley, John Deere's financial performance over this time period may have contributed to the stability of the Cedar Falls housing market. Strong commodity prices between 2007 to 2013 led to record setting John Deere earnings and stock prices (John Deere, 2012, 2013).
[13] The opinions expressed in this study are strictly those of the authors and are not those of the Black Hawk County Board of Supervisors.
[14] ArcGIS (Environmental Systems Research Institute, Inc.) was used in this study.

attendance zone (N = 179). Table 3 reports frequency statistics by year and spatial-temporal 'zone' (i.e., *MPLS, After, DiD*). For the time period considered, the counts of housing sales are relatively consistent across years.

[Tables 2 and 3 about here]

The summary statistics in Tables 2 and 3 provide support for our choice of the CCF neighborhood as a control group instead of the entire city of Cedar Falls. The CCF neighborhood is similar to the MPLS attendance zone for most structural and neighborhood characteristics. For example, the average house sold in all Cedar Falls was much larger (e.g., lot size, main living area, garage size, deck size) than the average house sold in either the CCF or MPLS areas. Further, houses sold in the CCF and MPLS areas were more likely to be rentals (33% and 40%, respectively) than the average house sold in all Cedar Falls (12%). Because of these differences, the average selling price for all Cedar Falls was significantly higher than the average selling price in the CCF and MPLS areas.

The average house selling price between 2009 and 2013 was approximately $132,000 in MPLS and $120,000 in CCF (2006$). On average, a house sold in either of these neighborhoods had about 2.9 bedrooms and 1.2 bathrooms. Houses sold in the CCF were slightly older at the time of sale (81 years) compared to houses in MPLS (67 years) which most likely accounts for the $12,000 difference in marginal average selling prices for the two regions. Houses in MPLS were more likely to be rental, had slightly larger lot sizes, and more main living area, number of fireplaces, and garage square feet than the average house sold in CCF. On the other hand, houses sold in CCF had more non-main living area, larger porches and decks, and were more vertical (i.e., more stories). However, most of these differences are minimal.

Census boundary files obtained from the Iowa Department of Natural Resources (DNR) GIS data clearinghouse were used to attach, through a spatial join, census identification numbers to the house sales. These identifiers were then used to attach neighborhood characteristics from the 2007-2011 American Community Survey to the house sales based on block group membership. Neighborhood characteristics include median house value, median rental value per month, and median year built. The CCF and MPLS neighborhoods are small in geographic scope and more homogeneous than larger-sized markets, thereby limiting our need to control for large variations in neighborhood characteristics (Clapp et al., 2008).

Another neighborhood characteristic included is a measure of school quality. Boundaries for elementary school attendance zones were provided by the Iowa Northland Regional Council of Governments. These include the boundaries for the MPLS attendance zone which were also cross checked with UNI archival documents. Spatial joins were used to attach school attendance zones to each house sale. Test scores for each elementary school were taken from the Iowa Tests of Basic Skills. The *4th grade test score* is the sum of the fourth grade average National Standard Score (NSS) for reading, math, and science; the score varies by year and elementary school attendance zone.[15]

To control for any university-related effect, straight-line/Euclidean distances were computed in GIS between each house sale and Campanile (a UNI landmark near the center of campus). *Employment*, measured as monthly employment in the Waterloo-Cedar Falls metropolitan area (U.S. Bureau of Labor Statistics, 2013), is included to capture variation in general economic conditions. Finally, we include a binary seasonal variable. *Summer sale*

[15] Housing sales were matched with the most recent test score which were assumed to be reported annually on August 1st. Besides the closure of MPLS, attendance zones did not change in Cedar Falls between 2006 and 2013.

controls for potentially different housing prices during the summer and takes a value of one if the house was sold between June 1 and August 15.

5.1 Empirical approach

We estimate the parameters of equation (1) using a nested models approach. For each model, the test group consists of 179 housing sales within the MPLS attendance zone before and after the closure and the control group consists of the 255 sales in the CCF neighborhood. In the first model, we consider only "zone" variables (i.e., DiD variables) and structural house characteristics. The second model adds neighborhood variables. The third model adds other variables that we believe might influence the Cedar Falls housing market – distance to UNI, summer sale, and local employment. For each model, the natural log of selling price is regressed on the relevant independent variables, while simultaneously estimating the spatial correlation parameters in equations (2) and (3) using *Proc Mixed* in SAS. If house prices in the MPLS attendance zone have been adversely affected by the closure of MPLS, then we would expect the *DiD* parameter estimate to be negative. We also expect the house characteristic and neighborhood characteristic parameter estimates to be positive (with the exception of age at sale, rental status, and median year built) and the distance to UNI coefficient estimate to be negative.

6. Results

SAS *Proc Mixed* regression results for the three models are provided in Table 4. Physical characteristics have the expected effects on housing sale prices. In all models, housing sale prices increase with main living area, non-main living area, deck size, number of fireplaces, garage size, porch size, lot size, number of stories, number of bathrooms, and number of bedrooms. Most of these variables are statistically significant across all models. Number of bedrooms, however, is not statistically significant in any model and number of bathrooms is only significant at the 10% level for the last two models. Lot size is statistically significant at the 10% level in the structural variables only model and structural & neighborhood variables model but is not significant in the full model. As expected, housing prices are negatively related to the age of the house at sale and rental status. Both of these variables are strongly significant across all models.

For neighborhood characteristics, median year built has a negative effect on housing sale prices and is the only neighborhood variable that is statistically significant (5% level). While the negative coefficient on test score is unexpected, a finding of insignificance is not unexpected. With little variation in school quality metrics between MPLS and the Cedar Falls public schools, housing prices may not be responsive to measurable school quality differences.[16] Inclusion of "other" variables (i.e., distance to UNI, summer sale, and employment) provides a slightly improved model fit but yields similar overall results. Proximity to UNI has a positive effect on house prices and is significant at that 10% level. Summer sale and local employment are not significant.

The *DiD* coefficient is negative and statistically significant across all models suggesting that the closing of MPLS had a negative effect on house prices within the attendance zone. The negative effect ranges from 6.8% in the full model to 7.2% in the structural variables only model or $8,891 to $9,509 (2006$) at the mean house value within the attendance zone. These effects are slightly smaller than the negative effects (9.9%) found in Bogart and Cromwell (2000). However, the closures considered by Bogart and Cromwell included multiple school closings, changes in school racial composition, and the introduction of a bus transportation system.

[Tables 4 about here]

[16] Full model results are robust to the removal of the test score variable; these results are available from the authors upon request.

The spatial variability parameter estimates are provided in Table 5. Each of the three models has a total variability or sill between 0.0294 and 0.0301 while the model with only Physical & Neighborhood variables has the highest pure error or nugget of 0.0135. The range of spatial correlation is also fairly consistent across models (221 to 226 feet). Thus, pairs of houses separated by more than roughly 225 feet are essentially uncorrelated.

[Table 5 about here]

7. Conclusions

Malcolm Price Laboratory School (MPLS) was a laboratory school that provided its students and potential teachers a quality education from 1914 until its closure in 2012. The suddenness of the school's closure provides a unique quasi-experimental opportunity in which housing prices can be examined for evidence of external effects associated with the laboratory school. Hedonic price theory suggests that, all else equal, housing values in the MPLS attendance zone should have gone down if the school's closure removed benefits to residents for which there are no close substitutes.

We used a quasi-difference-in-difference approach and housing sales data between January 1, 2009 and July 31, 2013 to evaluate the effects associated with the school and its closure. MPLS was the treatment group and the control group was an adjacent neighborhood located in central Cedar Falls with similar housing characteristics to the MPLS zone. We find that the closure of MPLS had a negative effect on house prices within the attendance zone. Depending on model specification, the school's closure reduced house values by 6.8% to 7.2%, or between $8,981 and $9,509 (2006$) at the mean house value. The closure of this school is unique from other school closures analyzed within the literature in that it was not closed due to under-performance and/or declining enrollment; the closing of MPLS was driven largely by exogenous changes in state funding and university budgeting decisions. Therefore, school quality and local economic issues do not confound our empirical analysis.

Acknowledgements

The authors gratefully acknowledge Lyn Countryman and the University of Northern Iowa Rod Library archive staff for their assistance in acquiring historical information on Malcom Price Laboratory School (MPLS) and Cedar Falls test scores. Data on Black Hawk county house sales were provided by the Black Hawk County Board of Supervisors. The content of this article, however, is the sole responsibility of the authors and does not reflect the views of the Black Hawk County Board of Supervisors.

References

Bennett, P., Peach, R., Peristiani, S., 2001. Structural change in the mortgage market and the propensity to refinance, Journal of Money, Credit and Banking 33(4), 955-975.

Besser, T., Recker, N., Agnitsch, K., 2008. The impact of economic shocks on quality of life and social capital in small towns, Rural Sociology 73(4), 580-604.

Black, S., 1999. Do better schools matter? Parental valuation of elementary education, The Quarterly Journal of Economics 114(2), 577-599.

Black, S., Machin, S., 2011. Housing valuations of school performances, in Hanushek, E., Machin, S., Woessmann, L. (Eds), Handbook of the Economics of Education, vol. 3, North-Holland (Elsevier), San Diego, CA, pp. 485-519.

Bogart, W., Cromwell, B., 2000. How much is a neighborhood school worth? Journal of Urban Economics 47, 280-305.

Brasington, D., 1999. Which measures of school quality does the housing market value, Journal of Real Estate Research 18(3), 395-413.

Brasington, D., Haurin, D., 2006. Educational outcomes and house values: a test of the value added approach, Journal of Regional Science 46(2), 245-268.

Burdick-Will, J., Keels, M., Schuble, T., 2013. Closing and opening schools: the association between neighborhood characteristics and the location of new educational opportunities in a large urban district, Journal of Urban Affairs 35(1), 59-80.

Clapp, J., Nanda, A., Ross, S., 2008. Which school attributes matter? The influence of school district performance and demographic composition on property values, Journal of Urban Economics 63, 451-466.

Cressie, N., 1993. Statistics for Spatial Data, Wiley, New York.

Deng, Y., Quigley, J., van Order, R., 2000. Mortgage terminations, heterogeneity and the exercise of mortgage options, Econometrica 68(2), 275-307.

Dhar, P., Ross, S., 2012. School district quality and property value: examining differences along school district boundaries, Journal of Urban Economics 71, 18-25.

Downes, T., Zabel, J., 2002. The impact of school characteristics on house prices: Chicago 1987-1991, Journal of Urban Economics 52, 1-25.

Ecker, M., 2003. Geostatistics: past, present and future. In Encyclopedia for Life Support Systems (EOLSS), developed under the Auspices of the UNESCO, Eolss Publishers, Oxford, UK. http://www.eolss.net.

Ericson, J., 2012a. College hill real estate a concern if price lab closes, Waterloo-Cedar Falls Courier, February 29, 2012, http://wcfcourier.com/news/local/college-hill-real-estate-a-concern-if-price-lab-closes/article_fcd84d6d-a4c0-5fa3-bd0b-d187eab1ade1.html (accessed January 2014).

Ericson, J., 2012b. Update – UNI President: cuts could be coming for academics, athletics and lab school, Waterloo-Cedar Falls Courier, February 17, 2012, http://wcfcourier.com/news/local/update---uni-president-cuts-could-be-coming-for/article_986f279a-58f0-11e1-baab-0019bb2963f4.html (accessed January 2014).

Figlio, D., Lucas, M., 2004. What's in a grade? School report cards and the housing market, The American Economic Review 94(3), 591-604.

Gibbons, S., Machin, S., 2005. Valuing rail access using transport innovations, Journal of Urban Economics 57, 148-169.

Gibbons, S., Machin, S., Silva, O., 2013. Valuing school quality using boundary discontinuities, Journal of Urban Economics 75, 15-28.

Gibbons, S., Silva, O., 2011. School quality, child wellbeing and parents' satisfaction, Economics of Education Review 30, 312-331.

Hayes, K., Taylor, L., 1996. Neighborhood school characteristics: what signals quality to homebuyers? Federal Reserve Bank of Dallas – Economic Review, fourth quarter.

Hoen, B., Brown, J., Jackson, T., Wiser, R., Thayer, M., Cappers, P., 2013. A spatial hedonic analysis of the effects of wind energy facilities on surrounding property values in the United States, Ernest Orland Lawrence Berkeley National Laboratory – Environmental Energy Technologies Division. LBNL Paper LBNL-63462E.

Horsch, E., Lewis, D., 2009. The effects of aquatic invasive species on property values: evidence from a quasi-experiment, Land Economics 85(3), 391-409.

Jinnai, Y., 2011. Who benefits from school choice? School competition, student sorting, and spillover effects, University of Rochester, Department of Economics working paper, http://www.sole-jole.org/12457.pdf (accessed January 2014).

John Deere, 2012. Deere & Company historical financial information, http://www.deere.com/wps/dcom/en_US/corporate/our_company/investor_relations/financial_data/factbook/factbook.page (accessed August 2013).

John Deere, 2013. 2013 archived earning releases, http://www.deere.com/wps/dcom/en_US/corporate/our_company/investor_relations/financial_data/financial_data_archives.page (accessed August 2013).

Kane, T., Riegg, S., Staiger, D., 2006. School quality, neighborhoods, and housing prices, American Law and Economics Review 8(2), 183-212.

Linh, T., 2013. Price Lab set for demolition, Waterloo-Cedar Falls Courier, May 17, 2013, http://wcfcourier.com/news/local/price-lab-set-for-demolition/article_a819e6dc-40d5-53f4-bc9b-8c857307a5b8.html (accessed January 2014).

Machin, S., 2011. Houses and schools: valuation of school quality through the housing market, Labour Economics 18, 723-729.

McMilin, 2010. Closing a school building: a systematic approach, National Clearinghouse for Educational Facilities, http://files.eric.ed.gov/fulltext/ED512699.pdf (accessed December 2013).

Peterson, G., Witthoft, S., Peterson, A., Iseminger, J., Briddle, G., 2012. Price Laboratory School, Rod Library Special Collections and University Archives, University of Northern Iowa, Cedar Falls, IA, http://www.library.uni.edu/collections/special-collections/building-histories/price-laboratory-school (accessed November 2013).

Quigg, L., 1993. Empirical testing of real option-pricing models, The Journal of Finance 48(2), 621-640.

Reinitz, J., 2010. Nine parents face charges in Price Lab tuition probe, Waterloo-Cedar Falls Courier, April 8, 2010, http://wcfcourier.com/news/local/nine-parents-face-charges-in-price-lab-tuition-probe/article_aa2ee1e8-427f-11df-93c7-001cc4c03286.html (accessed March 2014).

Ries, J., Somerville, T., 2010. School quality and residential property values: evidence from Vancouver rezoning, The Review of Economics and Statistics 92(4), 928-944.

Rosen, S., 1974. Hedonic prices and implicit markets: product differentiation in pure competition, The Journal of Political Economy 82(1), 34-55.

Schwartz, A., Ellen, I., Voicu, I., Schill, M., 2006. The external effects of place-based subsidized housing, Regional Science and Urban Economics 36, 679-707.

Sell, R., Leistritz, F.L., 1997. Socioeconomic impacts of school consolidation on host and vacated communities, Journal of the Community Development Society 28(2), 186-205.

Tu, C., 2006. How does a sports stadium affect housing values? The case of FedEx Field, Land Economics 81(3), 379-395.

U.S. Bureau of Labor Statistics, 2013. Local area unemployment statistics: Waterloo-Cedar Falls, IA Metropolitan, http://data.bls.gov/timeseries/LAUMT194794000000003?data_tool=XGtable (accessed August 2013).

Voicu, I., Been, V., 2008. The effect of community gardens on neighboring property values, Real Estate Economics 36(2), 241-283.

Zabel, J., Guignet, D., 2012. A hedonic analysis of the impact of LUST sites on house prices, Resource and Energy Economics 34, 549-564.

Tables

TABLE 1. Housing Price Index

(Base year is 2006)

Year	Index
2009	1.088
2010	1.111
2011	1.100
2012	1.084
2013	1.144

Note: 2013 only includes sales through July 31, 2013.

TABLE 2. Summary statistics

	All Cedar Falls (N = 1881)		CCF (N = 255)		MPLS (N = 179)	
Variable	Mean	S.D.	Mean	S.D.	Mean	S.D.
Dependent Variable						
Sale amount	180,637	93,178	120,457	38,175	132,076	34,177
Structural characteristics						
Main living area	1145	408	871	255	986	291
Non-main living area	374	545	481	455	384	442
Deck square feet	161	135	113	132	111	126
Number of fireplaces	0.55	0.56	0.26	0.45	0.40	0.51
Garage square feet	499	246	340	218	376	212
Porch square feet	73.3	81	81.4	83	78.7	84
Age of house at sale	42	32	80.6	28	66.5	30
Lot size	0.28	0.16	0.18	0.07	0.20	0.06
Number of stories	1.34	0.46	1.45	0.49	1.38	0.48
Number of bathrooms	1.24	0.47	1.11	0.32	1.17	0.43
Number of bedrooms	3.07	0.85	2.89	0.82	2.85	0.79
Rental	0.12	0.33	0.33	0.47	0.40	0.49
Neighborhood characteristics						
Median house value	173,402	43,157	134,759	12,372	171,701	40,967
Median rent value	702	273	788	315	667	153
Median year built	1969	16.9	1947	5.84	1961	16.4
4^{th} grade test score	641.5	17.0	647.4	40.5	641.3	15.5
Other variables						
Distance to UNI	8483	3312	6466	1056	3364	757
Summer sale	0.28	0.45	0.30	0.46	0.28	0.45
Employment	90,104	1000	90,095	969	90,191	981

TABLE 3 - Frequency (%)

Variable	All Cedar Falls	CCF	MPLS
Year 2009	371 (19.7%)	45 (17.6%)	31 (17.3%)
Year 2010	362 (19.2%)	52 (20.4%)	35 (19.6%)
Year 2011	349 (18.6%)	47 (18.4%)	37 (20.7%)
Year 2012	471 (25.0%)	66 (25.9%)	48 (26.8%)
Year 2013	328 (17.4%)	45 (17.6%)	28 (15.6%)
Zone			
MPLS	179 (9.5%)	0 (0%)	179 (100%)
After	717 (38.1%)	100 (39%)	68 (38%)
DiD product	68 (3.6%)	0 (0%)	68 (38%)

TABLE 4. Regression results

(N = 434)

	Structural variables only		Structural & Neighborhood variables		Full model	
Variable	Coeff.	*t*-stat	Coeff.	*t*-stat	Coeff.	*t*-stat
Intercept	11.13		18.70		18.13	
Zone						
MPLS	0.079***	3.37	0.110***	3.91	0.053	0.21
After	0.101***	4.60	0.106***	4.65	0.111***	4.49
DiD	-0.072**	-2.12	-0.069**	-2.03	-0.068**	-2.01
Structural characteristics						
Main living area	0.00038***	8.14	0.00038***	7.87	0.00038***	7.90
Non-main living area	0.00023***	6.63	0.00023***	6.61	0.00022***	6.48
Deck square feet	0.00013*	1.91	0.00012*	1.87	0.00011*	1.72
Number of fireplaces	0.0510**	2.36	0.0505**	2.34	0.0484**	2.23
Garage square feet	0.00014***	3.37	0.00014***	3.34	0.00015***	3.52
Porch square feet	0.00038***	3.45	0.00037***	3.31	0.00037***	3.35
Age of house at sale	-0.0030***	-6.67	-0.0034***	-6.86	-0.0034***	-6.92
Lot size	0.2941*	1.92	0.2882*	1.88	0.2236	1.44
Number of stories	0.0494**	2.14	0.053**	2.30	0.0557**	2.41
Number of bathrooms	0.0365	1.50	0.0435*	1.78	0.0412*	1.67
Number of bedrooms	0.0212	1.60	0.0182	1.37	0.0185	1.39
Rental	-0.124***	-6.38	-0.120***	-6.18	-0.125***	-6.37
Neighborhood characteristics						
Median house value			0.00039	0.68	0.00014	0.23
Median rent value			0.00006	1.38	0.00003	0.76
Median year built			-0.0037**	-2.51	-0.0033**	-2.25
4th grade test score			-0.0007	-0.96	-0.0008	-1.19
Other variables						
Distance to UNI					-0.00002*	-1.71
Summer sale					-0.026	-1.32
Employment					0.000001	0.12
-2 Res Log Likelihood	*-157.3*		*-111.4*		*-69.0*	
Marginal effect of closure on mean house in MPLS (2006$)	-$9,509		-$9,113		-$8,981	

Note: * p < 0.10, ** p < 0.05, *** p < 0.01

TABLE 5 – Spatial correlation parameter estimates

	Structural variables only	Structural & Neighborhood variables	Full model
Nugget	0.0125	0.0135	0.0134
Sill	0.0301	0.0296	0.0294
Range	223.1 feet	226.2 feet	220.7 feet

Figures

FIGURE 1 – Map of Cedar Falls

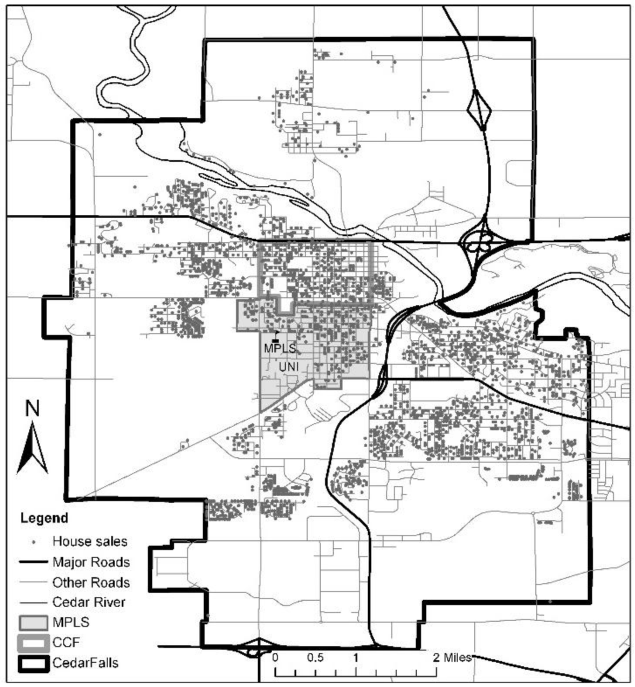

FIGURE 2 – Map of CCF and MPLS