Environmental/Energy Economics
Lecture 3: Hedonics and Local Public Goods

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Overview

- Standard demand theory investigates willingness-to-pay (WTP) for quantity
  - WTP for 5 versus 10 cans of coke
  - WTP for 10 versus 20 gallons of gas
  - Standard demand techniques estimate own- or cross-price elasticities for quantities of goods

Overview

- Hedonic models are about the demand for attributes or characteristics of goods
- Today we'll focus on houses
- What are other interesting examples?
  - [brainstorm]
  - Key requirements: need people purchasing goods with various attributes at (quasi-) market prices
  - Interested in market for attributes, not market for goods

Overview

- What are interesting hedonic aspects of houses?
  - Physical characteristics (boring): square footage, color, rooms, gold-plated windows, etc.
  - Local public goods (more interesting): schools, crime, pollution, industrial sites, parks, rivers
  - Peer effects (more interesting): neighbors, spillovers

Overview

Connecticut › New Haven › Downtown › 58 Trumbull St

58 Trumbull St, New Haven, CT 06510

3 beds, 4.2 baths, 5,706 sqft

This 5706 square foot single family home has 3 bedrooms and 4.2 bathrooms. It is located at 58 Trumbull St New Haven, Connecticut.

● For Sale

$799,000

Zestimate®: $657,291

Est. Mortgage:

$3,087/mo

Get Pre-Approved on Zillow

Find a trusted lender on Zillow

Overview

Why need a special theory for hedonic pricing?
Need a theory for interpretation:

- What is economic interpretation of the implicit price(s) for an attribute (rather than price for a good)?
  - [Why call it an *implicit* price?]
- How does this implicit price reflect consumer utility and firm cost parameters?
- What determines the market-clearing implicit price?

Also need a theory for estimation:

- How can we estimate implicit prices?
- How can we estimate utility and cost parameters?
- What are welfare consequences of changes in local public goods?

Overview

- Rosen's 1974 paper is still widely-cited and discussed, most often for housing
- Large and growing empirical literature on hedonics in education, crime, environment.
  - Open fields: health? Political economy? social insurance?
- The best recent papers either answer an open empirical question ("What is willingness-to-pay for school quality?")
- Or improve understanding of hedonic models ("Do consumers accurately perceive the attribute vector; if not, how measure welfare?")
- Recent literature comparing hedonic with discrete choice models

Rosen 1974

- n attributes

$z \equiv (z_1, z_2, ..., z_n)$ attribute vector
$p(z) = p(z_1, ..., z_n)$ maps characteristics to equilibrium prices
Assumptions:

- Exhaustive description of attributes
- Consumers accurately perceive attributes
- z a continuous space
- Consumers purchase a single good
- Prices are parametric (no market power for firms or consumers)

Rosen 1974

$p\left(z\right)$ Hedonic Price Function
In general, $p\left(z\right)$ is nonlinear

- Only linear with somewhat artificial assumptions

Rosen: Demand

- $U(x, z_1, ...z_n)$
- x other goods (numeraire, price normalized to one)
- y income, measured in terms of numeraire
- Consumers maximize utility subject to budget constraint.
- FOC:
$$\frac{\partial p}{\partial z_1} = p_i = \frac{U_{z_i}}{U_x}, i = 1, ..., n$$
- Bid function $\theta(z_1, ..., z_n; y, u)$ given by
$$U(y - \theta, z_1, , ..., z_n) = u$$
- WTP is $\theta(z; u, y)$.

Rosen: Demand

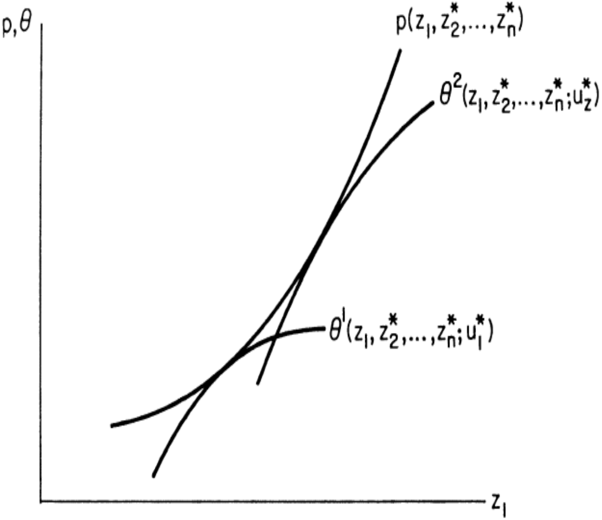


Fig. 1

Rosen: Demand

- $\theta(z; u, y)$ is WTP for z given fixed utility and income
- $p(z)$ is minimum price in the market
- So utility maximized when

$$\begin{aligned}\theta(z^*; u^*, y) &= p(z^*)\\ \theta_{z_i}(z^*; u^*, y) &= p_i(z^*)\end{aligned}$$

  where z^* and u^* are optimum
- In other works, people choose attributes where bid function is tangent to hedonic price function

Rosen: Demand

- Why do bid functions differ across consumers?
- Let α denote taste shifters (education, etc.)

$$U\left(x_1, z_1, ..., z_n; \alpha\right)$$

- Bid functions demend on y and α
- $F\left(y, \alpha\right)$ a joint distribution function

Rosen: Supply

- $M(z)$ units produced by a firm offering design z
- $C(M, z; \beta)$ total costs
- β firm cost shifters (factor prices, technology, R&D, etc.)
- A plant chooses M and z to maximize profit:

$$\begin{aligned} \pi &= Mp(z) - C(M, z_1, ..., z_n) \\ C_M(M, z_1, ..., z_n) &= \phi \end{aligned}$$

- At optimum z^*,

$$\begin{aligned} p_i(z^*) &= \phi_{z_i}(z_1^*, ..., z_n^*; \pi^*, \beta) \\ p(z^*) &= \phi(z_1^*, ...1, z_n^*; \pi^*, \beta) \end{aligned}$$

Rosen: Supply

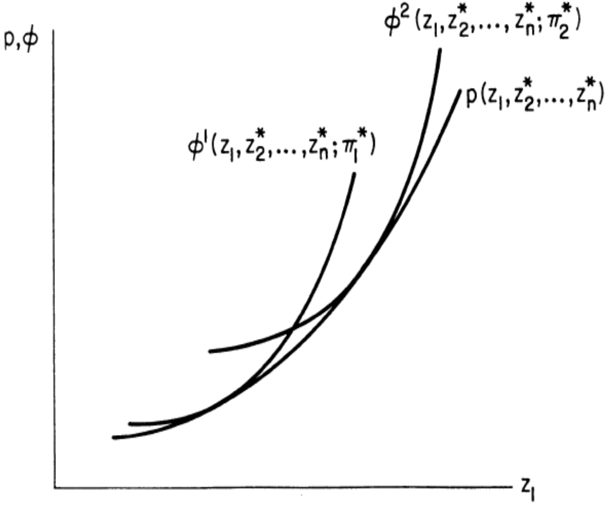


FIG. 2

Rosen: Equilibrium

[Draw hedonic price function with bid curves and offer curves]

Rosen: Equilibrium

- What is the economic interpretation of a hedonic price?
  - Tangency between bid and offer functions,
  - Common gradient is the implicit price function $p(z)$
- If no variance in cost shifters β, then all firms are identical and $p(z)$ reflects offer function
- If no variance in taste shifters α, then all consumers are identical and $p(z)$ reflects bid function

Rosen: Estimation

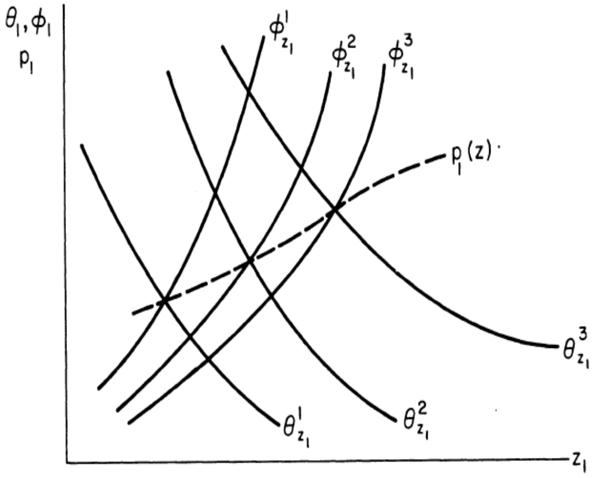


Fig. 4

Rosen: Estimation

- Two steps
- Step one: estimate hedonic price function
  - Regress product prices p on characteristics z
  - This recreates the agents' decision problem

Rosen: Estimation

- Step two: estimate bid and offer curves
  - For each buyer and seller, define the implicit marginal price that agent chooses

$$\frac{\partial p(z)}{\partial z_i} = \widehat{p}_i(z)$$

  - Then regress implicit prices on attributes, using taste and cost shifters as instruments

$$\begin{aligned} p_i(z) &= F^i(z_1, ..., z_n, Y_1) \\ &= G^i(z_1, ..., z_n, Y_2) \end{aligned}$$

Rosen: Estimation

Four possible cases (fourth is most realistic)

1. Firms have identical costs but consumers differ, so β has no variance
   - Then $\widehat{p}(z)$ identifies offer functions
2. Consumers have identical tastes but firms differ, so α has no variance
   - Then $\widehat{p}(z)$ identifies bid functions
3. If buyers are identical and sellers are identical
   - Market offers one quality
   - No product differentiation=no problem!
4. (typical case) distribution of buyers and sellers
   - Then it's a standard system of equations to identify
   - Need $\widehat{p}(z)$ to be nonlinear for identification, otherwise $\widehat{p}_i(z)$ has no variance and can't estimate
   - Linear $\widehat{p}(z)$ is a very peculiar/special case

Rosen: Side Note

Funny section on product standards

- Starts by assuming product standards must decrease welfare, then measures welfare loss
- This is correct in pure neoclassical world
- But typical motivation for product standards is externality, a behavioral anomaly (inattention, hyperpolic discounting, etc.), or another market failure

Rosen: Comments on Estimation

- Hundreds of papers apply Rosen's approach to estimating the first step (hedonic price function)
  - Many don't make clear what economic objects they're estimating and how they relate to utility & cost parameters
  - Estimating the hedonic price function is nontrivial and the usual econometric challenges apply
    - Buyers observe some characteristics, econometricians don't (omitted variables)
    - Buyers misperceive about some attributes (behavioral)
    - Discrete, not continuous set of goods
- Estimating Rosen's second step (bid curves, less often offer curves) less common and much more difficult
  - Huge literature in 1970s and 1980s pointing out problems with Rosen's method for second step
  - This is an open question
  - Various recent papers apply a method but don't really solve the problem
  - Need to solve this problem to measure effects of discrete changes in market conditions (e.g., regulation)

Black (1999) QJE

Overview

- This is a famous reduced-form paper
- It was early in the history of regression discontinuity
  - Some people cite Angrist and Lavy (1999) as popularizing RD in economics, and that was published in same year
- It's the typology of papers I gave, I'd put this in the first (showing stylized facts or magnitudes)
  - Until this paper, research on how school quality (test scores) relates to economic outcomes was a broken literature
  - This paper fixes it by introducing a new research design
  - Other good papers use same research design

Overview

- Observational regressions of test scores on school expenditures don't work well
  - Hanushek literature reviews
- Usual microeconometric problems
  - Omited variables bias
  - Reverse causality
  - Measurement error in X's
- Research design here: compare across Walk Zones
  - She calls them attendance district boundaries but this language can be confusing since both sides of the boundary need to be the same district.

Overview

- Main result: a 5 percent increase in elementary school test scores (1 s.d.) increases home prices by 2.1 percent, or $4,000 given mean home price of $188,000.
- This is half the magnitude we get from standard hedonic regressions

Research Design

- A standard hedonic regression is as follows:

$$\ln\left(price_{iaj}\right) = \alpha + X'_{iaj}\beta + Z'_{j}\delta + \gamma\, test_{aj} + \varepsilon_{iaj}$$

- p_{iaj} price of home i, walk zone a, school district j
- X_{iaj} bedrooms/bathrooms
- Z_j neighborhood and school district characteristics
- $test_{aj}$ mean test score in the school
- Problems here:
  - Omitted variables at school district level. Property tax rates, public goods.
  - Omitted variables within school district level: neighborhood characteristics
  - [Others?]

Research Design

- New research design:

$$\ln\left(price_{iab}\right) = \alpha + X'_{iab}\beta + K'_b\phi + \gamma test_a + \varepsilon_{iab}$$

- K_b are boundary dummies.
- This addresses both types of OVB
  - Walk zones are within a district
  - Can look very close to district boundaries

Data

- Boston suburbs 1993-1995
  - [External validity?]

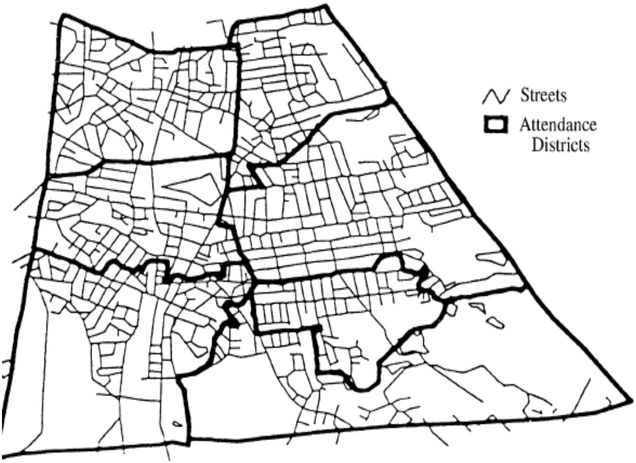


FIGURE I

Data

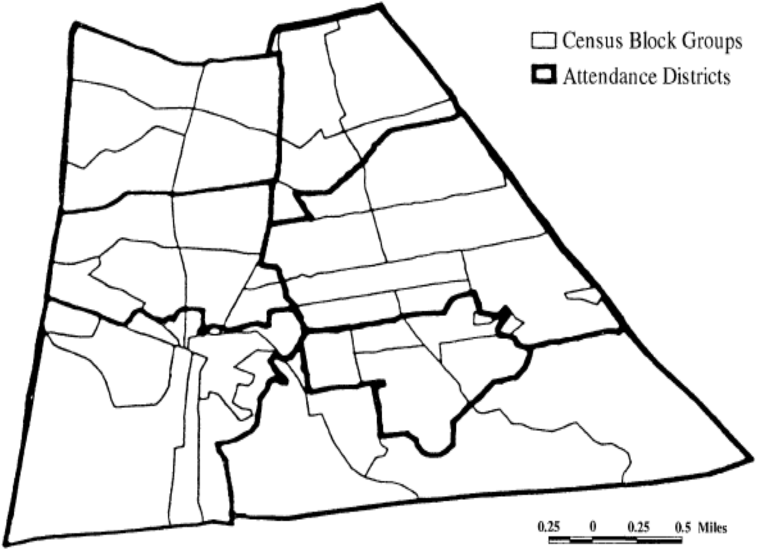


FIGURE II

Data

- Excludes districts with intra-district choice
  - [Why not use old walk zones for this district as a placebo test?]

Data

TABLE I
SUMMARY STATISTICS

Distance from boundary:	Full sample		0.35 mile		0.20 mile		0.15 mile	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
House price ($1993), tax adjusted[a]	188,076	113,923	185,799	108,081	184,955	108,111	186,387	114,001
ln (house price)	12.1	0.5	12.1	0.5	12.1	0.5	12.1	0.5
Bedrooms	3.2	0.9	3.2	0.9	3.2	0.9	3.2	0.9
Bathrooms	1.5	0.7	1.5	0.7	1.5	0.7	1.5	0.7
Age of building	53	36	57	35	59	35	59	35
Lot size (1000s)	17.3	15.0	14.3	12.5	14.0	12.4	14.1	12.6
Internal square footage (1000s)	1.8	0.8	1.8	0.8	1.8	0.8	1.8	0.8
School characteristics[b]								
Elementary school test score[c]	27.6	1.4	27.5	1.4	27.5	1.4	27.5	1.5

Data

TABLE II
REGRESSION RESULTS[a]
(ADJUSTED STANDARD ERRORS ARE IN PARENTHESES[b])
DEPENDENT VARIABLE = ln (HOUSE PRICE)

Distance from boundary:	(1) All houses[d]	(2) 0.35 mile from boundary (616 yards)	(3) 0.20 mile from boundary (350 yards)	(4) 0.15 mile from boundary (260 yards)	(5) 0.15 mile from boundary (260 yards)
Elementary school test score[c]	.035	.016	.013	.015	.031
	(.004)	(.007)	(.0065)	(.007)	(.006)
Bedrooms	.033	.038	.037	.033	.035
	(.004)	(.005)	(.006)	(.007)	(.007)
Bathrooms	.147	.143	.135	.167	.193
	(.014)	(.018)	(.024)	(.027)	(.028)
Bathrooms squared	−.013	−.017	−.015	−.024	−.025
	(.003)	(.004)	(.005)	(.006)	(.007)
Lot size (1000s)	.003	.005	.005	.005	.004
	(.0003)	(.0005)	(.0005)	(.0007)	(.0006)
Internal square footage (1000s)	.207	.193	.191	.195	.191
	(.007)	(.01)	(.01)	(.02)	(.012)
Age of building	−.002	−.002	−.003	−.003	−.002
	(.0003)	(.0002)	(.0005)	(.0006)	(.0004)
Age squared	.000003	.000003	.00001	.000009	.000005
	(.000001)	(.0000006)	(.000002)	(.000003)	(.000002)
Boundary fixed effects	NO	YES	YES	YES	NO
Census variables	Yes	No	No	No	Yes

Data

TABLE III
DIFFERENCES IN MEANS[a]

Distance from boundary:	Full sample		0.35 mile		0.20 mile		0.15 mile	
	Difference in means	T-statistic	Ratio of 0.35 to full sample[d]	T-statistic	Ratio of 0.20 to full sample[d]	T-statistic	Ratio of 0.15 to full sample[d]	T-statistic
ln (house price)	.045	3.82	0.85	3.32	0.85	3.17	0.93	3.17
Test score (sum of reading and math)	1.0	32.90	1.03	27.28	1.06	24.44	1.06	22.57
House characteristics								
Bedrooms	0.02	1.68	0.90	0.91	−0.35	−0.30	0.25	0.18
Bathrooms	0.03	2.98	0.23	0.52	−0.02	−0.05	−0.07	−0.12
Lot size	2011	11.39	0.22	2.14	0.24	1.95	0.12	0.83
Internal square footage	31	2.93	0.61	1.32	0.61	1.07	0.84	1.17
Age of building	−3.13	−6.92	0.75	−3.71	0.94	−3.76	1.09	−3.52
Neighborhood characteristics[c]								
Percent Hispanic	−.0008	−0.79	2.50	−1.35	2.50	−1.21	2.50	−1.26
Percent non-Hispanic black	−.0007	−1.50	0.43	−0.54	0.00	−0.07	−0.14	0.16
Percent 0–9 years old	.005	3.30	0.16	0.63	−0.08	−0.31	−0.30	−1.21
Percent 65+ years old	−.01	−2.04	0.40	−0.72	0.67	−1.28	0.60	−0.95
Percent female-headed households with children	−.001	−3.67	1.00	−3.17	1.20	−2.53	1.00	−2.38
Percent with bachelor's degree	.002	1.06	0.75	0.64	1.00	0.74	0.75	0.67
Percent with graduate degree	.008	3.32	0.88	2.77	0.88	3.02	0.88	3.31
Percent with less than high school diploma	−.005	−2.19	1.20	−2.02	0.80	−1.57	0.34	−0.64
Median household income	2,135	2.87	0.60	1.90	0.65	2.11	0.52	1.61

Data

TABLE IV
MAGNITUDE OF RESULTS[a]

	(1) Basic hedonic regression[d]	(2) 0.35 sample boundary fixed effects	(3) 0.20 sample boundary fixed effects	(4) 0.15 sample boundary fixed effects
Coefficient on elementary school test score[b]	.035 (.004)	.016 (.007)	.013 (.0065)	.015 (.007)
Magnitude of effect (percent change in house price as a result of a 5% change in test scores)[c]	4.9%	2.3%	1.8%	2.1%
$ Value (at mean tax-adjusted house price of $188,000 in $1993)	$9212	$4324	$3384	$3948
$ Value (at median tax-adjusted house price of $158,000 in $1993)	$7742	$3634	$2844	$3318

a. The results presented here are based on estimates from Table II, columns (1)–(4).
b. Test scores are measured at the elementary school level and represent the sum of the reading and math scores from the fourth grade MEAP test averaged over three years (1988, 1990, and 1992). *Source:* Massachusetts Department of Education.
c. Approximately a one-standard-deviation change in the average test scores at the mean.
d. Regression includes house characteristics, school characteristics measured at the school district level, and neighborhood characteristics measured at the census block group level. See Table II, column (1), and Appendix 1 for more complete results.

Data

TABLE V
SPECIFICATION TESTS
(HETEROSKEDASTICITY-ADJUSTED STANDARD ERRORS ARE IN PARENTHESES.)[a]
ALL REGRESSIONS INCLUDE BOUNDARY FIXED EFFECTS[b]

	(1) No roads[g]	(2) Pseudo-diffs-in-diffs	(3)	(4) Census variables[h]	(5) House quality	(6)	(7) Bedrooms[k]
Dependent variable	ln (price)	ln (price)[i]	ln (price)[j]	ln (price)	Internal square footage	Lot size	ln (price)
Elementary school test score[c]	.013 (.005)			.012 (.0066)	.045 (.104)	2.1 (1.6)	
High side of boundary dummy[d]		.024 (.009)					
Artificial control "hi" dummy[e]			−.001 (.009)				
Test score*(3 or more bedrooms dummy)							.017 (.007)
Test score*(1- or 2-bedrooms dummy)							.006 (.008)
House characteristics[f]	Yes	Yes	Yes	Yes			Yes
Quarter year dummies	Yes	Yes	Yes	Yes			Yes
N	8,190	6,824	6,023	10,651	9,355	10,398	10,657
Adjusted R^2	.6689	.6722	.6900	.6779	.3307	.4454	.6750

Data

APPENDIX 1: OTHER COEFFICIENTS FROM BASIC HEDONIC REGRESSION[a]
(HETEROSKEDASTICITY-ADJUSTED STANDARD ERRORS ARE IN PARENTHESES.)[b]

Dependent variable	log (house price)
School characteristics	
Per-pupil spending 1993 (1000s)	.044
	(.001)
Pupil/teacher ratio	−.005
	(.0035)
Preschool program	−.009
	(.009)
Property taxes	−.009
	(.003)
Neighborhood characteristics	
Distance to Boston	−.018
	(.002)
Distance to Boston squared	.0003
	(.00005)
Percent Hispanic	−.003
	(.204)
Percent black	−.26
	(.56)
Percent 0–9 years old	.27
	(.26)
Percent 65+ years old	.55
	(.10)
Percent female-headed households with children	−.88
	(.68)
Median household income (1000s)	.0002
	(.00006)
Percent with bachelor's degree	.58
	(.12)
Percent with graduate degree	1.22
	(.12)
Percent with less than high school diploma	−.55
	(.16)
N	22,679
Adjusted R^2	0.6423

Comments

- Paper doesn't describe or exploit relationship to hedonic model
  - It's just establishing that test scores are capitalized and estimating some aspect of the central tendency of that relationship
- No attempt to estimate second step
  - Does valuation differ by household? Paper implicitly says so (e.g., 1-2 bedroom versus 3+ bedroom homes)
- Does this mean spending is too low or high? This paper isn't designed to say
  - But see Cellini, Ferreira, and Rothstein, "The Value of School Facility Investments" (QJE 2010)
- Do people value neighbors on their block, and does that sorting confound these estimates?
  - Motivation for the next paper...

Comments

- My sense: spatial discontinuities/boundaries are an under-exploited research design
- More opportunities for it in other settings? Examples from last few years
  - Dell (Econometrica 2010):
    - Spanish colonists in Peru required labor taxes from villages within an arbitrary ring around silver mines
  - Ito (AER 2014):
    - Electric utilities have arbitrary zone boundaries, giving similar people within a town different electricity prices
    - Probably also true for natural gas, water, etc. utilities
  - Doyle, Graves, Gruber, Kleiner (JPE forthcoming):
    - Ambulances have arbitrary coverage boundaries and take people to different hospitals

Bayer, Ferreira, McMillan (JPE)

Overview

- This paper builds on Black
  - Innovation: embed her boundary RD in a mixed logit (a.k.a. random coefficients logit a.k.a. Berry-Levinsohn-Pakes a.k.a. BLP)
  - Also, use census microdata with block-level demographics
  - Measure importance of sorting around walk zone boundaries
- Main conclusion: part of apparent WTP for school quality is reality WTP for neighbors attending that school

Data

- 1990 Population census microdata: restricted-access version
  - You can access through Yale-Census RDC (37hh basement)
  - Exact replies from long-form respondents (15 percent of Americans)
  - Individual: race, age, education, income
  - Household: owned/rented, value, property tax, rooms, bedrooms, age, etc.
  - Geography: census block (100 people)

Data

- Sample selection: six counties in San Francisco
- 650,000 people, 242,000 households
- Census respondents only report home price in 26 bins
- They impute the home price measure
  - Interval regressions (tobit generalization) for each of 45 PUMAs. Control for rooms, bedrooms, structure type, dwelling age, neighborhoods, property tax * tenure, hosuehold head age, etc.
  - Then use fitted value as the dependent variable in regressions
  - [Somewhat messy and artificial. Use raw data or adapt BLP to interval regressions?]
  - [Introduces non-classical measurement error correlated with X's?]
- Mean home price $300,000 (in 1990–Bay Area)

Data

- Also have complete home sales data 1992-1996
  - Probably from Dataquick
  - You can possibly get these also, though they are expensive
- No demographics, but they add some using HMDA
  - Merge via census tract, loan amount, date, lender name

Data

- Attendance zone maps for 195 elementary schools (a third of schools in Bay Area)
- Exclude boundaries coincedent with major roads, city boundaries, etc.

Data

TABLE 1

Sample Statistics Comparing the Full Sample with Houses within 0.20 Mile of a Boundary

	Full Sample (N = 242,100)		Sample: Within 0.20 Mile of Boundary				
	Mean (1)	Standard Deviation (2)	Boundary Sample (N = 27,548): Mean (3)	High Test Score Side (N = 13,612): Mean (4)	Low Test Score Side (N = 13,936): Mean (5)	Difference in Means: Col. 4 − Col. 5 (6)	Test of Difference: t-Statistic (7)
Housing prices:							
House value (if owned)	297,700	178,479	250,005	259,475	240,756	18,719	4.15
Monthly rent (if rented)	744	316	678	688	669	18.80	1.73
School quality:							
Average test score	527	74	507	544	471	74	25.44
Housing characteristics:							
1 if unit owned	.60	.49	.54	.55	.53	.02	.89
Number of rooms	5.11	1.99	4.96	5.02	4.90	.12	1.56
1 if built in 1980s	.14	.35	.11	.11	.11	.00	−.31
1 if built in 1960s or 1970s	.39	.49	.34	.35	.33	.01	.84
Elevation	210	179	176	178	173	6	1.64
Population density	.43	.50	.39	.38	.40	−.02	−1.38
Neighborhood sociodemographics:							
% census block group white	.68	.23	.61	.63	.60	.03	3.40
% census block group black	.08	.16	.18	.17	.20	−.03	−3.15
% census block group with college degree or more	.44	.20	.41	.44	.39	.05	6.18
Average block group income	54,742	26,075	46,271	47,718	44,857	2,861	2.61

Note.—This table reports summary statistics for the key variables included in the analysis. The boundary sample includes all houses located within 0.20 mile of a boundary with another school attendance zone. A house is considered to be on the "high" ("low") side of a boundary if the test score at its local school is greater (less) than the corresponding test score for the closest house on the opposite side of the attendance zone boundary. Sample statistics are reported for the high and low sides of boundaries for which the test score gap is in excess of the median gap (38.4 points) in cols. 4 and 5, respectively. Col. 7 reports the t-statistic for a test of the hypothesis that the mean of the variable listed in the row heading does not vary across school attendance zone boundaries. This test conditions on boundary fixed effects (so as to compare houses on opposite sides of the same boundary) and adjusts for the clustering of observations at the census block group level.

Data

TABLE 2
SAMPLE STATISTICS COMPARING THE FULL SAMPLE WITH HOUSES WITHIN 0.10 MILE OF A BOUNDARY

	FULL SAMPLE (N = 242,100)		SAMPLE: WITHIN 0.10 MILE OF BOUNDARY				
	Mean (1)	Standard Deviation (2)	Boundary Sample (N = 15,122): Mean (3)	High Test Score Side (N = 7,824): Mean (4)	Low Test Score Side (N = 7,298): Mean (5)	Difference in Means: Col. 4 − Col. 5 (6)	Test of Difference: t-Statistic (7)
Housing prices:							
House value (if owned)	297,700	178,479	244,506	251,742	236,749	14,993	3.95
Monthly rent (if rented)	744	316	667	673	661	11.8	1.05
School quality:							
Average test score	527	74	505	542	466	75	21.00
Housing characteristics:							
1 if unit owned	.60	.49	.51	.51	.51	.00	−.20
Number of rooms	5.11	1.99	4.88	4.88	4.87	.01	.14
1 if built in 1980s	.14	.35	.12	.12	.11	.01	1.12
1 if built in 1960s or 1970s	.39	.49	.30	.30	.30	.01	.48
Elevation	210	179	164	166	162	4	1.53
Population density	.43	.50	.41	.41	.41	.00	−.20
Neighborhood sociodemographics:							
% census block group white	.68	.23	.60	.61	.58	.03	2.82
% census block group black	.08	.16	.20	.19	.22	−.03	−3.13
% census block group with college degree or more	.44	.20	.41	.43	.38	.05	5.24
Average block group income	54,742	26,075	44,831	45,657	43,945	1,711	1.70

NOTE.—This table reports summary statistics for the key variables included in the analysis. The boundary sample includes all houses located within 0.20 mile of a boundary with another school attendance zone. A house is considered to be on the high (low) side of a boundary if the test score at its local school is greater (less) than the corresponding test score for the closest house on the opposite side of the attendance zone boundary. Sample statistics are reported for the high and low sides of boundaries for which the test score gap is in excess of the median gap (38.4 points) in cols. 4 and 5, respectively. Col. 7 reports the t-statistic for a test of the hypothesis that the mean of the variable listed in the row heading does not vary across school attendance zone boundaries. This test conditions on boundary fixed effects (so as to compare houses on opposite sides of the same boundary) and adjusts for the clustering of observations at the census block group level.

Motivating Evidence

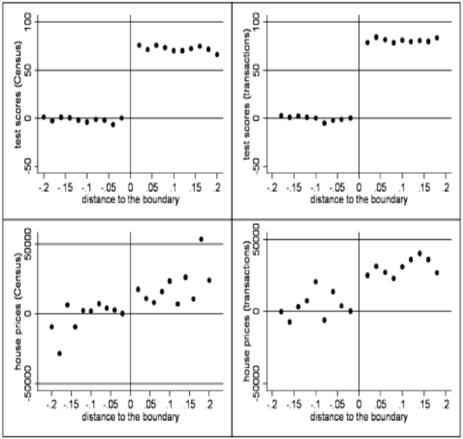


FIG. 1.—Test scores and house prices around the boundary. Each panel is constructed using the following procedure: (i) regress the variable in question on boundary fixed effects and on 0.02-mile band distance to the boundary dummy variables; (ii) plot the coefficients on these distance dummies. Thus a given point in each panel represents this conditional average at a given distance to the boundary, where negative distances indicate the low test score side.

Motivating Evidence

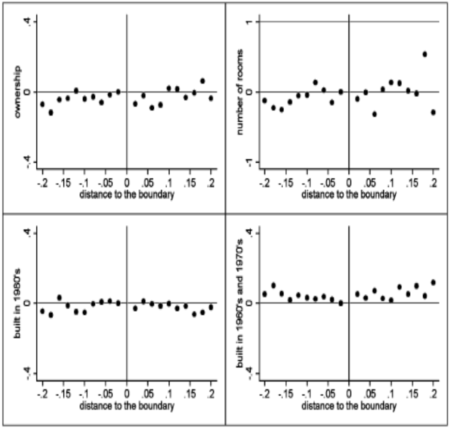


FIG. 2.—Census housing characteristics around the boundary. Each panel is constructed using the following procedure: (i) regress the variable in question on boundary fixed effects and on 0.02-mile band distance to the boundary dummy variables; (ii) plot the coefficients on these distance dummies. Thus a given point in each panel represents this conditional average at a given distance to the boundary, where negative distances indicate the low test score side.

Motivating Evidence

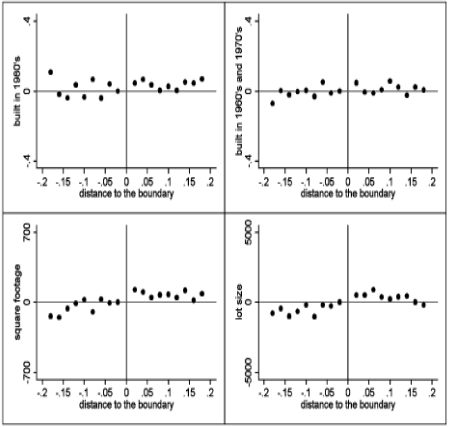


FIG. 3.—Transactions data housing characteristics around the boundary. Each panel is constructed using the following procedure: (i) regress the variable in question on boundary fixed effects and on 0.02-mile band distance to the boundary dummy variables; (ii) plot the coefficients on these distance dummies. Thus a given point in each panel represents this conditional average at a given distance to the boundary, where negative distances indicate the low test score side.

Motivating Evidence

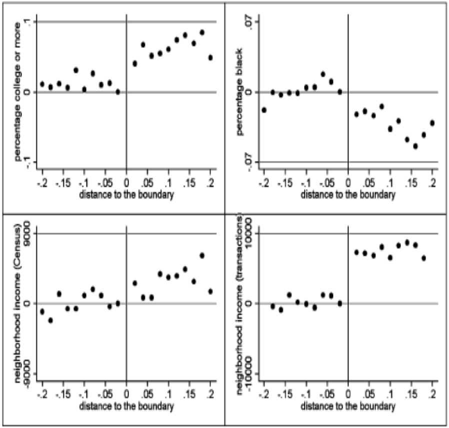


FIG. 4.—Neighborhood sociodemographics around the boundary. Each panel is constructed using the following procedure: (i) regress the variable in question on boundary fixed effects and on 0.02-mile band distance to the boundary dummy variables; (ii) plot the coefficients on these distance dummies. Thus a given point in each panel represents this conditional average at a given distance to the boundary, where negative distances indicate the low test score side.

Hedonic Price Function

$$p_h = \beta X_h + \theta_{bh} + \xi_h$$

h house (dwelling, not household!)
X_h Neighborhood and housing characteristics
θ_{bh} boundary fixed effects

Hedonic Price Function

TABLE 3
KEY COEFFICIENTS FROM BASELINE HEDONIC PRICE REGRESSIONS

	SAMPLE			
	Within 0.20 Mile of Boundary (N = 27,548)		Within 0.10 Mile of Boundary (N = 15,122)	
Boundary fixed effects included	No	Yes	No	Yes
	A. Excluding Neighborhood Sociodemographic Characteristics			
	(1)	(2)	(5)	(6)
Average test score (in standard deviations)	123.7	33.1	126.5	26.1
	(13.2)	(7.6)	(12.4)	(6.6)
R^2	.54	.62	.54	.62
	B. Including Neighborhood Sociodemographic Characteristics			
	(3)	(4)	(7)	(8)
Average test score (in standard deviations)	34.8	17.3	44.1	14.6
	(8.1)	(5.9)	(8.5)	(6.3)
% census block group black	−99.8	1.5	−123.1	4.3
	(33.4)	(38.9)	(32.5)	(39.1)
% block group with college degree or more	220.1	89.9	204.4	80.8
	(39.9)	(32.3)	(40.8)	(39.7)
Average block group income (/10,000)	60.0	45.0	55.6	42.9
	(4.0)	(4.6)	(4.3)	(6.1)
R^2	.59	.64	.59	.63

NOTE.—All regressions shown in the table also include controls for whether the house is owner-occupied, the number of rooms, year built (1980s, 1960–79, pre-1960), elevation, population density, crime, and land use (% industrial, % residential, % commercial, % open space, % other) in 1-, 2-, and 3-mile rings around each location. The dependent variable is the monthly user cost of housing, which equals monthly rent for renter-occupied units and a monthly user cost for owner-occupied housing, calculated as described in the text. Standard errors corrected for clustering at the school level are reported in parentheses.

Hedonic Price Function

TABLE 4
HEDONIC PRICE REGRESSIONS: AVERAGE TEST SCORE, ALTERNATIVE SAMPLES
SAMPLE: WITHIN 0.20 MILE OF BOUNDARY

	NEIGHBORHOOD SOCIODEMOGRAPHICS			
	Excluded		Included	
	(1)	(2)	(3)	(4)
Boundary fixed effects included	No	Yes	No	Yes
Baseline results (N = 27,548)	123.7	33.1	34.8	17.3
	(13.2)	(7.6)	(8.1)	(5.9)
Schools versus immediate neighbors:				
A. Including school peer and teacher measures (N = 27,548)	95.0	32.1	31.5	22.6
	(17.9)	(10.4)	(9.3)	(8.5)
Alternative measures of neighborhood characteristics:				
B. Including block and block group measures (N = 27,548)			36.0	19.8
			(7.8)	(5.7)
C. Including block and alternative block group measures (N = 27,548)			33.7	23.8
			(7.3)	(5.6)
Other robustness checks:				
D. Dropping top-coded houses (N = 26,579)	86.6	29.5	20.3	16.1
	(9.9)	(6.6)	(7.7)	(5.7)
Only owner-occupied housing units:				
E. Using census-reported house value (N = 15,139)	64,891	14,874	27,883	9,376
	(7,474)	(3,197)	(5,047)	(2,460)
F. Using prices from transactions sample (N = 10,171)	34,262	12,210	14,208	9,176
	(4,958)	(3,108)	(2,886)	(2,738)

NOTE.—The dependent variable in specifications A–D is the monthly user cost of housing, which equals monthly rent for renter-occupied units and a monthly user cost for owner-occupied housing, calculated as described in the text; the dependent variable in specification E is the market value of the house self-reported in the census; the dependent variable in specification F is the transaction price reported in our transactions data set. Specifications A–E are based on our census sample and include controls for whether the house is owner-occupied, the number of rooms, year built (1980s, 1960–79, pre-1960), elevation, population density, crime, and land use (% industrial, % residential, % commercial, % open space, % other) in 1-, 2-, and 3-mile rings around each location. Specification F is based on our transactions data set and includes the same controls as in the other specifications along with additional controls for square footage and lot size. Standard errors corrected for clustering at the school level are reported in parentheses.

Hedonic Price Function

TABLE 5

HEDONIC PRICE REGRESSIONS: KEY NEIGHBORHOOD SOCIODEMOGRAPHIC CHARACTERISTICS, ALTERNATIVE SAMPLES
SAMPLE: WITHIN 0.20 MILE OF BOUNDARY

	% Black	% College-Educated	Average Income (/$10,000)	% Black	% College-Educated	Average Income (/$10,000)
Boundary fixed effects included	No	No	No	Yes	Yes	Yes
Baseline results (N = 27,548)	−99.8	220.1	60.0	1.5	89.9	45.0
	(33.4)	(39.9)	(4.0)	(38.9)	(32.3)	(4.6)
Schools versus immediate neighbors:						
A. Including school peer and teacher measures (N = 27,548)	−38.2	215.6	60.7	−13.4	97.8	45.4
	(36.2)	(41.0)	(4.0)	(40.3)	(32.9)	(4.6)
Alternative measures of neighborhood characteristics:						
B. Including block and block group measures:						
Block measures (N = 27,548)	2.9	63.2	28.4	10.3	58.8	24.9
	(17.6)	(13.3)	(1.9)	(17.0)	(11.2)	(1.6)
Block group measures (N = 27,548)	−98.0	145.1	37.3	−13.7	36.0	25.2
	(37.6)	(42.2)	(4.1)	(38.8)	(34.0)	(4.4)
C. Including block and alternative block group measures:						
Block measures (N = 27,548)	.0	65.6	29.7	8.2	63.7	26.3
	(17.2)	(12.7)	(2.0)	(16.8)	(10.9)	(1.7)
Block group measures (N = 27,548)	−101.2	126.4	42.2	−4.2	−12.5	30.3
	(37.1)	(43.5)	(4.1)	(45.3)	(41.4)	(4.2)
Other robustness checks:						
D. Dropping top-coded houses (N = 26,579)	−116.6	229.9	47.0	1.3	129.2	38.0
	(31.0)	(39.6)	(5.4)	(38.9)	(34.1)	(5.2)
Only owner-occupied housing units:						
E. Using census-reported house value (N = 15,139)	−54,289	46,071	25,816	−4,101	−12,437	14,353
	(16,013)	(21,796)	(1,997)	(12,407)	(15,899)	(1,864)
F. Using prices from transactions sample (N = 10,171)			15,810			6,780
			(2,470)			(1,990)

NOTE.—See the note to table 4.

Sorting Model

$$\max_h V_h^i = \alpha_X^i X_h - \alpha_p^i p_h - \alpha_d^i d_h^i + \theta_{bh} + \xi_h + \varepsilon_h^i$$

V_h^i Indirect utility
X_h observable home characteristics (size, age, etc.)
p_h home price
d_h^i distance from residence to person i's workplace [fixed]
ξ_h utility term common to everyone
ε_h^i logit error

Sorting Model

$$\alpha_j^i = \alpha_{0j} + \sum_{k=1}^{K} \alpha_{kj} z_k^i$$

z_k^i individual covariates (educatoin, income, race, etc.)
α_j^i person i's preference for characteristic j (X, Z, d, p)

Estimation

Rewrite as

$$V_h^i = \delta_h + \lambda_h^i + \varepsilon_h^i$$

δ_h mean utility of dwelling h common to all households
λ_h^i aspect of utility for household h which is specific to household i
ε_h^i unobserved preferences beyond ξ_h

$$\delta_h = \alpha_{0X} X_h - \alpha_{0p} p_h + \theta_{bh} + \xi_h$$

$$\lambda_h^i = \left(\sum_{k=1}^{K} \alpha_{kX} \; z_k^i \right) X_h - \left(\sum_{k=1}^{K} \alpha_{kp} z_k^i \right) p_h - \left(\sum_{k=1}^{K} \alpha_{kd} z_k^i \right) d_h$$

Estimation

First, estimate mean utility δ_h and heterogeneous parameters λ_h^i via maximum likelihood.

By logit assumption, choice probabilities are

$$P_h^i = \frac{\exp\left(\delta_h + \lambda_h^i\right)}{\sum_k \exp\left(\delta_k + \lambda_k^i\right)}$$

Log likelihood function is

$$l = \sum_i \sum_h I_h^i \ln\left(P_h^i\right)$$

$I_h^i = 1\{i \text{ chooses } h\}$

Estimation

Second step, decompose δ into observable and unobservable components. Note that

$$p_h + \frac{1}{\alpha_{0p}}\delta_h = \frac{\alpha_{0X}}{\alpha_{0p}}X_h + \frac{1}{\alpha_{0p}}\theta_{bh} + \frac{1}{\alpha_{0p}}\xi_h$$

This shows relationship of hedonic regression to sorting model.

Estimation: Stylized Example

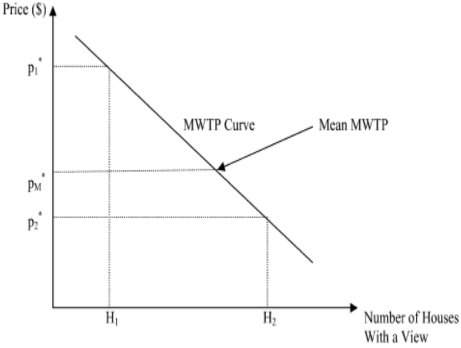
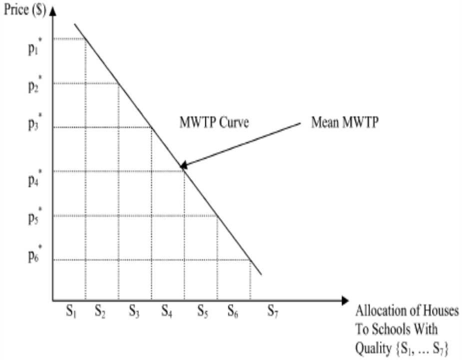


FIG. 5.—Demand for a view of the Golden Gate Bridge

Estimation: Stylized Example



Estimation: Stylized Example

If households have homogeneous preferences, then δ_h same for all houses, equal to constant K

$$\alpha_{0X} X_h - \alpha_{0p} p_h + \theta_{bh} + \xi_h = K$$

This implies our original hedonic model:

$$p_h = \frac{\alpha_{0X}}{\alpha_{0p}} X_h + \frac{1}{\alpha_{0p}} X_h + \frac{1}{\alpha_{0p}} \theta_{bh} + \frac{1}{\alpha_{0p}} \xi_h$$

Estimation: Price Instrument

To estimate price equation, need both δ_h and an instrument for p_h

$$p_h + \frac{1}{\alpha_{0p}}\delta_h = \frac{\alpha_{0X}}{\alpha_{0p}}X_h + \frac{1}{\alpha_{0p}}\theta_{bh} + \frac{1}{\alpha_{0p}}\xi_h$$

Approach: BLP / Hausman instruments.

- Prices are affected by attributes of substitute products
- Characteristics of distant neighborhoods affect prices in my neighborhood
- Assume homes within 3 miles affect my home price, homes > 3 miles away don't

Estimation: Price Instrument

Two step procedure

1. Estimate following equation with standard controls and instruments (land characteristics of areas > 3 miles away):

$$\delta_h = \alpha_{0X} X_h - \alpha_{0p} p_h + \theta_{bh} + \xi_h$$

   Land use variables (FN 36): percent industrial, percent commercial, percent residential, percent open space, percent other, in concentric rings

2. Calculate predicted market-clearing prices if $\xi = 0$. Boil this down to a single instrument reflecting these "exogenous" features of the housing market > 3 miles away from a house. Text says: the first-stage has t-statistic of 10.3 to 17.7

Estimation: Summary

TABLE 6

SUMMARY OF THE ESTIMATION PROCEDURE AND KEY IDENTIFYING ASSUMPTIONS

Step and Description of Estimation Procedure	Key Identifying Assumptions
Heterogeneous Sorting Model	
1. Estimate vector of mean indirect utilities, δ, and the interaction parameters in λ in eq. (4) via maximum likelihood	1. Identification is based on the notion of revealed preference: the coefficients are selected to maximize the probability each household makes its observed housing choice
2. Estimate instrumental variable regression of vector of mean indirect utility δ on observable characteristics and boundary fixed effects according to eq. (5), using an instrumental variable for housing price	
a. Housing prices: Following industrial organization literature, correlation between housing price and unobserved housing/neighborhood quality addressed using instrument based on exogenous characteristics of housing stock and neighborhoods beyond a 3-mile threshold	2*a*. Exogenous features of housing stock and land usage located more than 3 miles from a house affect housing price through the market equilibrium but do not affect utility directly

Estimation: Summary

b. School quality: Correlation of school quality and unobserved neighborhood quality addessed by including boundary fixed effects and detailed controls for neighborhood sociodemographics	2*b.* (i) Housing characteristics vary continuously across boundaries; (ii) measures for neighborhood race/ethnicity, education, and income included in regression control fully for sorting across boundaries
c. Neighborhood sociodemographics: Correlation between neighborhood sociodemographic composition and unobserved neighborhood quality addressed by including boundary fixed effects in the analysis	2*c.* (i) Housing characteristics vary continuously across boundaries; (ii) variation in neighborhood sociodemographics at boundaries is fundamentally driven by differences in school quality; (iii) average test score and other school characteristics included in specifications control fully for differences in school quality
Homogeneous Sorting Model: Hedonic Price Regression	
1. Under the assumption of homogeneous preferences, estimation reduces to hedonic price regression, given by eq. (1). Boundary fixed effects are included in the regression to account for endogeneity of school quality and neighborhood sociodemographics	1. See assumptions 2*b* and 2*c* above: the same identifying assumptions for school quality and neighborhood sociodemographics apply

Estimation: Results

TABLE 7
DELTA REGRESSIONS: IMPLIED MEAN WILLINGNESS TO PAY
SAMPLE: WITHIN 0.20 MILE OF BOUNDARY (N = 27,458)

Boundary fixed effects included	No	Yes
	A. Excluding Neighborhood Sociodemographic Characteristics	
	(1)	(2)
Average test score (in standard deviations)	97.3	40.8
	(14.0)	(5.5)
	B. Including Neighborhood Sociodemographic Characteristics	
	(3)	(4)
Average test score (in standard deviations)	18.0	19.7
	(8.3)	(7.4)
% block group black	−404.8	−104.8
	(41.4)	(36.9)
% census block group Hispanic	−88.4	−3.5
% block group with college degree or more	183.5	104.6
	(26.4)	(31.8)
Average block group income (/10,000)	30.7	36.3
	(3.7)	(6.6)

NOTE.—All regressions shown in the table also include controls for whether the house is owner-occupied, the number of rooms, year built (1980s, 1960–79, pre-1960), elevation, population density, crime, and land use (% industrial, % residential, % commercial, % open space, % other) in 1-, 2-, and 3-mile rings around each location. The dependent variable is the monthly user cost of housing, which equals monthly rent for renter-occupied units and a monthly user cost for owner-occupied housing, calculated as described in the text. Standard errors corrected for clustering at the school level are reported in parentheses.

Estimation: Results

TABLE 8
HETEROGENEITY IN MARGINAL WILLINGNESS TO PAY FOR AVERAGE TEST SCORE AND NEIGHBORHOOD SOCIODEMOGRAPHIC CHARACTERISTICS

	Average Test Score +1 SD	Neighborhood Sociodemographics: +10% Black vs. White	+10% College-Educated	Block Group Average Income +$10,000
Mean MWTP	19.69	−10.50	10.46	36.3
	(7.41)	(3.69)	(3.18)	(6.60)
Household income (+$10,000)	1.38	−1.23	1.41	.86
	(.33)	(.37)	(.21)	(.12)
Children under 18 vs. no children	7.41	11.86	−16.07	2.37
	(3.58)	(3.03)	(2.25)	(1.17)
Black vs. white	−14.31	98.34	18.45	−1.16
	(7.36)	(3.93)	(4.52)	(2.24)
College degree or more vs. some college or less	13.03	9.19	58.05	.31
	(3.57)	(3.14)	(2.33)	(1.40)

NOTE.—The first row of the table reports the mean marginal willingness to pay for the change reported in the column heading. The remaining rows report the difference in willingness to pay associated with the change listed in the row heading, holding all other factors equal. The full heterogeneous choice model includes 135 interactions between nine household characteristics and 15 housing and neighborhood characteristics. The included household characteristics are household income, the presence of children under 18, and the race/ethnicity (Asian, black, Hispanic, white), educational attainment (some college, college degree or more), work status, and age of the household head. The housing and neighborhood characteristics are the monthly user cost of housing, distance to work, average test score, whether the house is owner-occupied, number of rooms, year built (1980s, 1960–79, pre-1960), elevation, population density, crime, and the racial composition (% Asian, % black, % Hispanic, % white) and average education (% college degree) and household income for the corresponding census block group. Standard errors are reported in parentheses.

Discussion

- This paper combines Black's research design with BLP's differentiated products estimator
- Most papers which just combine two standard approaches get standard results and aren't great papers
- This paper gets a new approach to estimating household-level demand for neighborhood goods
- Partly because it demonstrates the power of census confidential microdata
- As in many differentiated products settings, credible instruments are hard to find
- The paper is good because its results are interesting, but the paper's method is more of a contribution than its results.

Introduction

- Davis, Lucas W. 2004. "The Effect of Health Risk on Housing Values: Evidence from a Cancer Cluster." American Economic Review 94(5): 1693-1704.
- Churchill County, Nevada (population 23,982)
- Before 1997, no history of pediatric leukemia
- Since 1997, 15 children diagnosed with acute lymphocytic leukemia, sixteenth with acute myelogenous leukemia
- Joint panel by Nevada Health Department and U.S. CDC: no identifiable cause
  - No common characteristic among case families: occupational hazard, neighborhood, or water

Introduction

- National incidence suggests that Churchill County should see one case every five years
- Little attention when 1-2 cases found in 1997 or 1999
- Local and national news attention when eight cases diagnosed in 2000 and four more in 2001
- Similar clusters of pediatric leukemia in several places
  - Maryvale, Arizona; Marion, Ohio; Toms River, New Jersey; Woburn, Massachusetts
  - "Cancer cluster" a medical term, clustering widespread

Introduction

- Cause of lekemia is unknown
  - Only known causes: chronic exposure to benzene; extraordinary doses of irradiation; certain types of chemotherapy
  - Contaminants studied: petrochemicals, heavy metals, pesticides, volatile organic compounds, solvents, consumer chemicals
  - Challenge: leukemia has a latency period of weeks to years
  - So current leukemia rates don't always reflect current health risk
- Treatment: 2-3 years of chemotherapy
  - Or bone-marrow transplant
- Five year survival rates: 85 percent for acute lymphocytic leukemia and 45 percent for acute myelogenous leukemia

Location Choice Model

- i indexes locations
- S states of world, indexed by s
- π_{is}^{s}: probability of realizing state s in location i and period t
- c_{it}: aggregate consumption of non-housing goods
- $u^G \geq u^B$: utility of good and bad states of the world.
- Household utility in location i and period t:

$$U\left(\pi_{it}, c_{it}\right) = \left(1 - \pi_{it}\right) u^G\left(c_{it}\right) + \pi_{it} u^B\left(c_{it}\right)$$

- Price of housing adjusts to equalize utility across locations
- This framework assumes risk π_{it} is known, but households infer it from data.

Estimating Cancer Risk

- Four measures
  - Cumulative number of cases
  - Cumulative nmber of newspaper articles in Proquest with "leukemia" and "Churchill County" or "Fallon" (the county seat
  - Linear spline that's zero through 1999, rises by 1/24 each month through 2001, then equals one
  - Bayesian learning process.
    - Households in location i draw health outcomes from Bernoulli distribution with parameter π_i
    - Households don't know π_i but update beliefs with DeGroot (1970) process
    - Assume prior for 1997. Prior is national incidence rate, but explore others

Estimating Cancer Risk

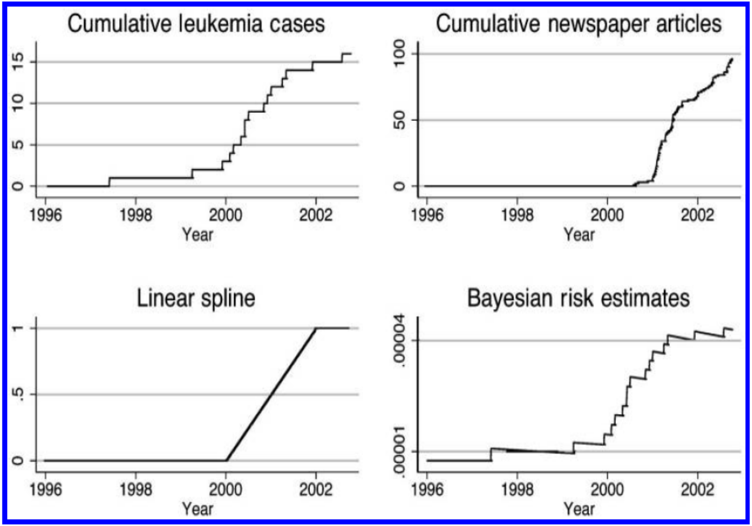


FIGURE 1. INCIDENCE RATES INCREASE AFTER 1999:
ALTERNATIVE MEASUREMENTS OF PEDIATRIC LEUKEMIA RISK FOR CHURCHILL COUNTY, NEVADA

Estimating Cancer Risk

- Caveats
  - Risk perceptions could depend on leukemia rates in nearby locations
  - This paper uses a comparison county, and it hasn't experienced increased pediatric leukemia rates or other cancer rates
  - Households in Churchill County may believe that whatever's responsible for increased pediatric leukemia increased their risk for other health problems

Housing Records

- Home sales data from Church County assessor and Lyon County assessor
- All sales of single-family residences, 1990-2002
- Lyon County has similar median income and median home values to Church County

Housing Records

TABLE 1—COMPARING THE TREATMENT AND CONTROL COUNTIES

	Churchill (n = 2495)	Lyon (n = 3683)
Housing characteristics:		
Mean sales price	$116,060	$119,723
	(52,791)	(55,060)
Mean lot size (acres)	1.42	1.16
	(3.97)	(6.21)
Mean interior floor space (square feet)	1493	1480
	(461)	(438)
Mean building age (years)	16.9	10.8
	(20.8)	(15.6)
Mean class (range 1–5)	1.75	2.16
	(.59)	(.76)
Demographic characteristics:		
Population	23,982	34,501
Persons per square mile	4.9	17.3
Percentage under 18	28.9	27.1
Percentage over 65	11.9	13.7
Percentage white	84.2	88.6
Percentage high-school graduates	85.1	81.5
Percentage college graduates	16.7	11.3
Homeownership rate	65.8	75.8
Percentage multi-unit	11.7	8.1
Percentage below poverty	8.7	10.4
Median household income	$40,808	$40,699
Labor market characteristics:		
Percentage employed in services	28.6	25.8
Percentage employed in government	23.8	12.1
Percentage employed in trade	18.6	18.0
Percentage employed in F.I.R.E.*	8.6	7.2
Percentage employed in agriculture	6.3	8.2
Percentage employed in construction	5.8	9.6
Percentage employed in manufacturing	5.6	14.1
Percentage employed in utilities	2.2	3.3
Percentage employed in mining	0.5	1.7
Percentage of labor force unemployed	6.2	7.4

Notes: The housing characteristics are for single-family residences sold during the 1990–1998 period. Standard deviations are in parentheses. Sales prices have been deflated to reflect year 2000 prices using the Nevada Real Estate Price Index. Demographic characteristics are from the 2000 Census. Percentage multi-unit refers to the percentage of housing units in multi-unit structures. Median household income is for 1999. Employment statistics come from the Bureau of Economic Analysis for 1998.

* F.I.R.E. includes finance, insurance, and real estate.

Estimation

$$PRICE_{jct} = \beta_1 X_{jct} + \beta_2 RISK_{ct} + \eta_{ct} + \varepsilon_{jct}$$

- j houses
- c county
- t time
- X housing characteristics (acres, floor space, building age, condition, county FE, year FE, month FE)
- $RISK$: cancer risk

Estimation

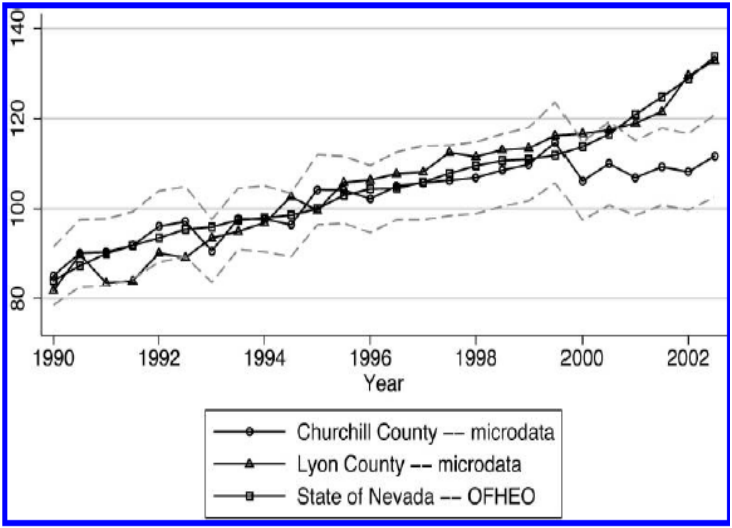


Figure 2. Assessing the Validity of the Counterfactual: House-Price Indices for Single-Family Residences, 1990–2002

Estimation

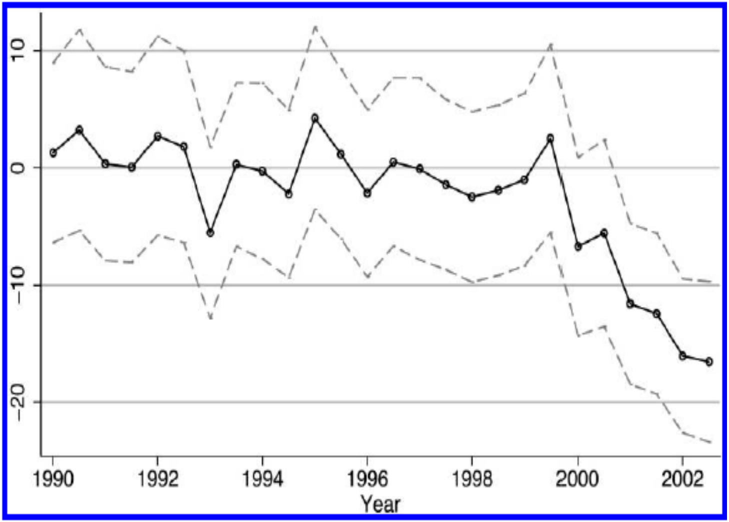


Figure 3. Fall in Housing Prices after 1999:
Percentage Difference between Churchill County HPI and Nevada HPI

Estimation

Table 2—Difference-in-Difference Estimator: Mean Log Sales Price before and during Leukemia Increase

	1990–1999	2000–2002	Difference
Churchill County	11.587	11.550	−0.037
	(0.408)	(0.407)	
	n = 2800	n = 796	
Lyon County	11.627	11.667	0.040
	(0.403)	(0.342)	
	n = 4323	n = 2285	
Relative difference			−0.077
			(0.019)

Estimation

TABLE 3—THE EFFECT OF HEALTH RISK ON HOUSING VALUES

	OLS (1)	OLS (2)	FE
Leukemia risk (linear spline)	−0.123	−0.156	−0.140
	(0.013)	(0.017)	(0.015)
Lot size (acres)	0.011	0.012	—
	(0.002)	(0.002)	
Lot size squared	−1.88E-05	−2.02E-05	—
	(3.20E-06)	(3.18E-06)	
Floor space (square feet, 100s)	0.054	0.044	—
	(0.001)	(0.001)	
Building age (years)	−0.009	−0.006	—
	(0.001)	(0.001)	
Building age squared	3.57E-05	1.20E-05	—
	(8.61E-06)	(8.42E-06)	
Churchill County dummy	—	0.068	—
		(0.009)	
Class dummies	no	yes	—
Year dummies	no	yes	yes
Month dummies	no	yes	yes
n	10204	10204	4922
R^2	0.60	0.63	0.05

Notes: The sample consists of sales of single-family residences from 1990 to 2002 from both counties. The dependent variable is sales price in logs. The linear spline is zero through 1999, rises by 1/24 each month during 2000 and 2001, and then takes the value of one. For the control county the linear spline is equal to zero for all periods. Standard errors are corrected for heteroskedasticity and correlated errors within county-month groups.

Estimation

TABLE 4—COMPARING DIFFERENTIALS FOR DIFFERENT-SIZED HOMES

	OLS	FE
Small homes	−0.147	−0.159
<1,250 square feet	(.043)	(.040)
	n = 2817	n = 1469
Medium homes	−0.165	−0.166
1,250–1,500 square feet	(.025)	(.026)
	n = 3010	n = 1496
Large homes	−0.153	−0.120
1,500–2,000 square feet	(.021)	(.020)
	n = 3147	n = 1371
Very large homes	−0.141	−0.126
>2,000 square feet	(.039)	(.047)
	n = 1230	n = 586

Notes: The OLS specification includes housing characteristics, class dummies, time dummies, monthly dummies, and a county dummy. The FE specification includes time and monthly dummies. The mean 1990–1999 sales prices for Churchill County for the four groups are $84,600, $109,000, $135,900, and $183,100, respectively. Standard errors are corrected for heteroskedasticity and correlated errors within county-month groups.

Estimation

TABLE 5—LIFETIME ESTIMATES OF RISK AND THE STATISTICAL VALUE OF PEDIATRIC LEUKEMIA

	Standard Prior	Low Mean Prior	High Mean Prior	Low Variance Prior	High Variance Prior
Risk estimate 1997	2.59	1.29	5.18	2.59	2.59
	(1.71)	(1.21)	(2.42)	(1.25)	(2.53)
Risk estimate 2002	14.5	13.6	16.4	9.82	22.6
	(3.48)	(3.37)	(3.71)	(2.23)	(5.64)
VPL-least squares	\$5.55	\$5.39	\$5.88	\$9.20	\$3.28
	(0.60)	(0.58)	(0.64)	(0.99)	(0.36)
VPL-fixed effects	\$5.00	\$4.88	\$5.26	\$8.29	\$2.97
	(0.46)	(0.44)	(0.48)	(0.75)	(0.28)

Notes: The first two rows of the table report estimated lifetime pediatric leukemia risk per 10,000 individuals as of January 1, 1997, and January 1, 2002, with the standard deviation of the beliefs distribution in parenthesis. The second two rows report the value of a statistical case of pediatric leukemia (VPL) in millions of U.S. dollars (2000) with standard errors in parenthesis. The VPL estimates are derived from ten separate regressions. The OLS specification includes housing characteristics, class dummies, time dummies, monthly dummies, and a county dummy. The FE specification includes time and monthly dummies. Standard errors are corrected for heteroskedasticity and correlated errors within county-month groups.