WATERING THE GRASS AND COOLING OFF: IMPLICATIONS FOR WATER POLICY

H. Allen Klaiber
The Ohio State University

V. Kerry Smith
Arizona State, NBER, RFF

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OVERVIEW

- Urban heat island and landscape
- Challenges of valuing environmental / ecosystem services
- Abbott and Klaiber (2011) solution: utilizing within and between-neighborhood/time information to its full extent
- Implications for water policy

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Urban Heat Island and Landscape

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Urbanization: Choices and Challenges

- Green landscaping associated with large water use in arid environments like Phoenix
  - Provides numerous benefits: aesthetics, recreation, reductions in temperature
- Transformation of natural landscape to concrete and heat absorbing materials increases heat retention
  - For arid, warm climates these increase electric and water usage as well as reducing "comfort"
- Policymakers concerned with long-run availability of cheap water need information on the valuations of these competing effects
  - Nearly 75% of water use in Phoenix occurs outdoors!

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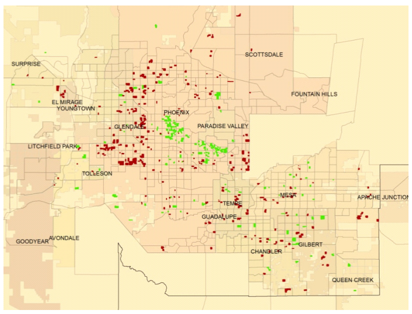
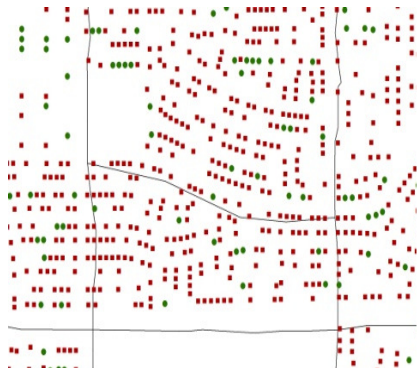
Green Landscape



- Both parcel and neighborhood amenity flows are likely
- Correlated with spatial unobservables

- Obtained from remote sensing satellite imagery



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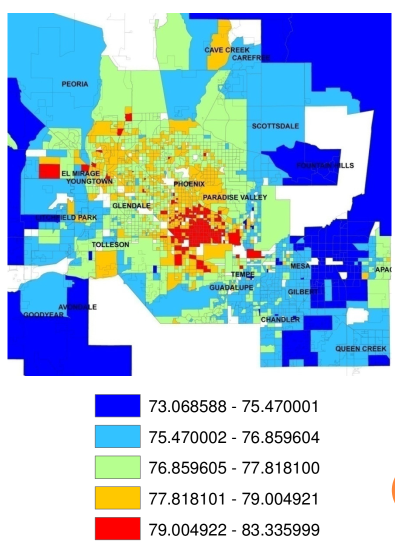
Urban Heat Island – Phoenix Temperatures

- Challenges:
  - Difficult to measure
  - Fluctuate annually
  - Correlated with density, development, landscape
- Measurement:
  - PRISM data to obtain block group temperature
  - Focus on July minimum



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Spatial Scale and Capitalization

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The case of non-market services

Hedonic Price Review

- Homebuyers (or renters) view houses as "bundles" of desired characteristics and select a home to maximize their welfare given the constraints they face.
- If markets are reasonably competitive and in equilibrium then:
  - Willingness to pay of homeowners for a small change in an amenity can be recovered
- Environmental amenities can be viewed as capital assets yielding multiple flows of services

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Spatial Scale and Non-Market Services

- Services propagate over a range of spatial scales due to
  - Natural/physical conditions
  - Human perceptions
  - Institutional structure
- Some services are linked through physical processes, but vary over different spatial scales
  - E.g. Green landscaping and temperature
- <u>Big problem</u>: unobserved spatial variables are likely highly correlated with (dis) amenities of interest → Fixed Effects

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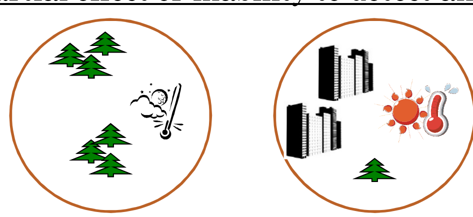
Spatial FE Approaches

- BUT, FE estimation makes strong assumptions on the *scale(s) of amenity capitalization* relative to the *scale of variation*
  - If spatial effects are broader than the maximum extent of capitalization → traditional omitted variable bias.
  - If spatial effects are subsumed by maximum extent of capitalization → <u>bias from recovery of partial effect or inability to detect an effect at all!</u>



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The Hausman-Taylor Estimator (1981)

- Define a "panel" as repeated transactions in a spatial (block group) and year combination (jt)
- Partition regressors:
  - Varying within panel (exogenous, endogenous) "fine" variables
  - Constant within panel (exogenous, endogenous) "coarse" variables
- Identify all "fine" variables using "within" variation.
- Identify *endogenous* coarse variables using exogenous "fine" variables as instruments
  - Exploit different scales of variation to use exogenous "fine" variables as essentially two different variables!

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Data and Results

Controlling for omitted variables and spatial scale

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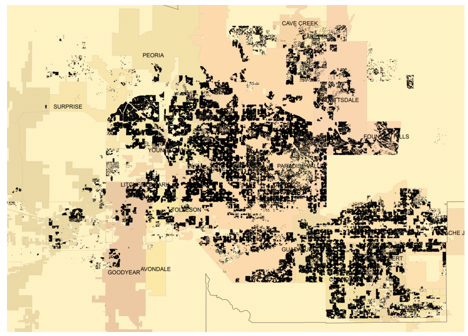
Data

- 551,199 transactions between 1998 and 2004
  - Contain full suite of housing characteristics
  - Data on distances to CBD and highways, distances and proximity to parks, Census demographics
- 1,646 Census 2000 block groups
  - 10,021 panels with data
- Prices deflated by Case-Schiller and converted to annual rents



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Instruments

- Temperature is correlated with elevation and density – are these exogenous?
  - Form instruments using mean elevation, mean distance to subdivision open space, and mean subdivision open space adjacency

Hausman Test for Exogeneity		Correlation
Variable	p-value	w/Temperature
Adjacent subd. Open	0.3549	-0.1304
Subd open distance	0.145	0.266
Elevation	0.6295	-0.2789
Joint Test	0.326	

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HT Results (semi-log)

Variable	Estimate	Std Err[a]	z-stat
Within Panel Varying, Exogenous			
Adjacent subd. Open	0.0486	0.0035	13.9
Subd open distance	-0.0195	0.0083	-2.35
Elevation	0.1316	0.0212	6.2
Within Panel Invariant, Endogenous			
Temperature (block group)	-0.0360	0.0184	-1.96
Within Panel varying, Endogenous			
Square footage	0.0505	0.0010	52.09
Lot acres	0.3453	0.0229	15.09
# Rooms	-0.0156	0.0012	-13.58
# stories	-0.0744	0.0034	-22.18
# bathrooms	0.0465	0.0024	19.59
Age	-0.0093	0.0004	-25.62
Garage	0.0540	0.0030	18.04
Pool	0.0472	0.0011	41.47
Green landscaping (parcel)	0.0123	0.0014	8.86
Green landscaping (subdivision)	0.0832	0.0077	10.76

[a]Robust standard errors calculated using 200 non-parametric clustered bootstraps

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Discussion

- Using the monthly mean rental price of $1398
  - MWTP for reduction of 1 degree is $50
  - MWTP for green parcel landscaping is $17
  - MWTP for green neighborhood is $116
- Important for policymakers to know household valuations for landscape and heat mitigation to design effective water policies
  - Substantial premium associated with these likely limits the effectiveness of simple rate changes
  - Suggests non-price changes are required to alter behavior

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Comments?

- E-mail: klaiber.16@osu.edu

A MODEL

Dimensions and Superscripts

i = house — *1 = endogenous*
j = block group — *2 = exogenous*
t = sale year

$$P_{ijt} = \alpha_0 + \alpha_1 X_{ijt}^1 + \alpha_2 X_{ijt}^2 + \alpha_3 Z_{jt}^1 + \alpha_4 Z_{jt}^2 + \eta_{jt} + \epsilon_{ijt}$$

- X contains within-panel varying characteristics such as sqft, acreage, green lawns, pools, …
  - Contains subdivision wide measures of green landscape
  - Many of these are likely confounded by omitted variables
- Z contains characteristics that do not vary within panels such as census demographics, distances, etc.
  - Also contains block group temperature
- η_{jt} are unobserved panel random effects

Model (continued)

- Define

$$\delta_{jt} = \eta_{jt} + \alpha_3 Z_{jt}^1 + \alpha_4 Z_{jt}^2$$

$$P_{ijt} = \alpha_0 + \alpha_1 X_{ijt}^1 + \alpha_2 X_{ijt}^2 + \delta_{jt} + \epsilon_{ijt}$$

- Fixed effects estimation cannot identify the marginal effects of Z^1
  - Random effects can but cannot address omitted variable bias
- Need an approach that preserves identification of broad scale effects *and* accounts for potential omitted variables bias
  - Hausman-Taylor estimator

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The Hausman-Taylor Est. – Steps

1. Define panels based on {j,t} dimensions

$$P_{ijt} = \alpha_0 + \alpha_1 X_{ijt}^1 + \alpha_2 X_{ijt}^2 + \alpha_3 Z_{jt}^1 + \alpha_4 Z_{jt}^2 + \eta_{jt} + \epsilon_{ijt}$$

2. Use within (fixed effects) estimator to recover consistent estimates of $\alpha_0, \alpha_1, \alpha_2$ and get consistent estimates of

$$\delta_{jt} = \eta_{jt} + \alpha_3 Z_{jt}^1 + \alpha_4 Z_{jt}^2$$

3. Get first-stage consistent estimates of α_3 and α_4 by regressing these "within" residuals on Z_{jt}^1 and Z_{jt}^2.

4. Utilize the information in hand to estimate the variances of the error components and perform a GLS transformation on the regression

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Steps – Continued

$$\widetilde{P}_{ijt} = \alpha_0 \widetilde{1}_{jt} + \alpha_1 \widetilde{X}^1_{ijt} + \alpha_2 \widetilde{X}^2_{ijt} + \alpha_3 \widetilde{Z}^1_{jt} + \alpha_4 \widetilde{Z}^2_{jt} + \widetilde{\epsilon}_{ijt}$$

Omitted variables are still in the transformed error term, but transformed to be homoskedastic and free of serial correlation.

5. Conduct an instrumental variables regression using the following instruments

   $\widehat{X}^1_{ijt}$, $\widehat{X}^2_{ijt}$, $\overline{X}^2_{ijt}$, $\widetilde{Z}^2_{jt}$

   - Use fixed effects estimation for all “fine” variables
   - Use variation in the panel mean of exogenous fine characteristics as instruments for endogenous “coarse variables

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