Sufficient Statistics for Measuring the Value of Changes in Local Public Goods: Does Chetty's Framework Inform Lind?

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Sufficient Statistics for Measuring the Value of Changes in Local Public Goods: Does Chetty's Framework Inform Lind?

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Abstract

The performance of quasi-experimental methods applied to changes in non-market goods depends on the ability of reduced form models to accurately measure willingness to pay. When exogenous changes are non-marginal, the accuracy of the reduced form approximations is not well understood. Further complicating the performance of reduced form models is that the true representation of the non-market good in household utility functions may differ from the perceptions of that good as captured in the reduced form model. This paper evaluates a series of before/after quasi-experiments where the true model is known and examines the performance of these methods under a variety of conditions. We find that performance is impacted by the scale of the change and that differences in perceptions of the amenity between the reduced form model and the underlying utility function play an important role in determining the performance of quasi-experimental applications. For researchers interested in non-market goods where the true representations of changes in relation to the underlying utility function are unknown, the notion of perceived measures of the non-market good in reduced form models should receive considerable attention.

Keywords: Welfare Measurement; Quasi-Experiment; Assignment Model; Perceptions; Non-Marginal Change; Open Space

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I. Introduction

The first-stage hedonic model has been a workhorse for researchers interested in valuing local public goods for over a quarter century. Many studies employing the hedonic model have focused on topics as diverse as air quality, the impact of superfund sites, and the value of open space. In each case the studies attempt to consider a local change in what is described as a public good. Over thirty years ago, Lind [1973] argued that land rents captured, as a first approximation, the economic value of improvements associated with *local* public goods. While numerous authors have attempted to refine his argument, to our knowledge no one has evaluated the factors influencing the quality of the first order approximation. Starrett [1983], for example, provides a general theory of how this capitalization occurs under a variety of assumptions. As he correctly points out, an underlying assumption in the capitalization framework is that any change is first order, so that equilibrium exists and is defined by the estimated parameters.

While most studies acknowledge that the first-stage hedonic is appropriate for analyzing small changes in local public goods, little attention has been given to identifying exactly what distinguishes a “small” change from a “big” change. Recent work by Kuminoff et al. [2008b] shows that the existence of a large change in local public goods is likely to result in differences between experimental welfare estimation approaches and structural welfare estimation approaches, but does not address the dual questions of how local public goods are characterized in individual preferences and what “large” means in the context of hedonic estimation. The absence of research addressing the factors influencing the quality of the approximation stands in contrast to the emphasis on the role of assumptions about the functional form for the hedonic price function as initially considered by Cropper et al. [1988] and more recently examined by

Kuminoff et al. [2008a]. Concern over the ability of the hedonic function to capture adequately the effects of large changes in local public goods is often cited as a motivation for pursuing other estimation strategies such as the vertical and horizontal sorting models developed by Epple et al. [1999] and Bayer and Timmins [2005], respectively.

Recently Chetty [2008] has suggested the issues raised by the literature on quasi-experiments are part of a broader debate which considers whether reduced form modeling strategies to estimate the effects of public policy are superior to structural models. At the heart of this discussion is how to interpret the reduced form estimates which emphasize transparent identification strategies for measuring effects but are short on interpreting the relationship between what is measured and the benefits associated with the policy intervention. We argue his analysis is directly relevant to the questions posed by Lind and Starrett. Chetty argues that for some models, including hedonic models comparable to the cases Lind considered, the reduced form models can offer sufficient statistics that have welfare interpretations. His models all maintain quasi-linear preferences and very simple characterizations of the role for local public goods. Thus the relevance of the Lind conjectures and our analysis of how public goods should be measured and what constitutes a small change remain and are also relevant to other normative interpretations of the quasi experimental results.

A challenge in addressing the question of how size and characteristics of changes in local public goods are capitalized arises because we have little basis for connecting what we observe in practice to the simple analytical representations of public goods in formal models. The implications of alternative descriptions of how these goods enter households' utility functions are not appreciated. In this paper, we present a model that captures differences between the perceived measure of open space in a reduced form model and the actual measure of open space in the underlying utility function. Using this framework, we examine a series of before and after quasi-experiments to evaluate the performance of reduced form models ability to accurately measure welfare associated with non-marginal changes in public goods.

The remainder of the paper is structured as follows. The next section outlines the structure of the model defining utility along with an open space component formed as a composite of both size and miles of trails. The third section describes the simulation framework we use to evaluate the performance of quasi-experiments under various degrees of large changes in open space. The fourth section describes the quasi-experiments we evaluate. The penultimate section discusses the results from our quasi-experiments. Finally, the last section concludes with suggestions for additional work.

II. Model specification

We define the utility for a household, i, choosing house, j, using the following Generalized Leontief utility specification

$$U_{ij} = \gamma O_d^{\frac{1}{2}} + \beta_0 (M_i - P_j)^{\frac{1}{2}} + \sum_{l=1}^{K} \beta_l X_{lj}^{\frac{1}{2}}, \tag{1}$$

where O_d is a measure of open space unique to each open space feature indexed by d, M_i is household specific income, P_j is housing price, and X_{lj} are a set of house specific characteristics. The coefficients are normalized such that $\beta_0 = 1$. We further decompose the composite open space measure using the following CES function

$$O_d = \left(\alpha S_d^{\rho} + (1-\alpha) T_d^{\rho}\right)^{\frac{1}{\rho}}, \tag{2}$$

where S_d is the size of the open space in 100s of acres and T_d is the length of trails measured in miles. As only the index of open space enters the utility function, it is necessary to estimate the parameters α and ρ which are needed to form the open space index.

Figure 1 provides a graphical depiction of the isoclines associated with the composite open space measure, O_d. The point A is a particular combination of park size and trail length that characterizes a unique open space feature. Moving along an isocline other combinations of park size and trail length providing identical levels of open space are obtained. Following a change to an existing park, such as acquiring more land and adding trails, the open space measure could change to a new isocline containing point B. The slope at each point captures the rate of substitution between trail length and size, while the distance between isoclines captures the relative scale differences between two levels of open space.

To estimate the parameters of the CES open space function, we utilize the CES structure combined with marginal implicit prices obtained from an estimated first-stage hedonic model. Taking derivatives of the utility function with respect to S and T provides the following first-order conditions

$$\begin{aligned}\frac{\partial U}{\partial S} &= \frac{\alpha}{2}\gamma O^{-\frac{1}{2}}\left(\alpha S_d^{\rho} + (1-\alpha)T_d^{\rho}\right)^{-\frac{1}{\rho}} S^{\rho-1} - \frac{1}{2}\beta_0 (M-P)^{-\frac{1}{2}}\frac{\partial P}{\partial S} = 0 \\ \frac{\partial U}{\partial T} &= \frac{(1-\alpha)}{2}\gamma O^{-\frac{1}{2}}\left(\alpha S_d^{\rho} + (1-\alpha)T_d^{\rho}\right)^{-\frac{1}{\rho}} T^{\rho-1} - \frac{1}{2}\beta_0 (M-P)^{-\frac{1}{2}}\frac{\partial P}{\partial T} = 0\end{aligned} \tag{3}$$

Forming a ratio of the two first-order conditions results in the following ratio

$$\frac{\partial P}{\partial S}\bigg/\frac{\partial P}{\partial T} = \frac{\alpha S^{\rho-1}}{(1-\alpha)T^{\rho-1}}, \tag{4}$$

and upon natural logs, equation (4) is rewritten as

$$\ln\left({}^{\pi_S}/_{\pi_T}\right) = \ln\left(\frac{\alpha}{1-\alpha}\right) + (\rho - 1)\ln\left(\frac{S}{T}\right), \tag{5}$$

where π_S and π_T are marginal values for open space size and miles of trails, respectively.

We recover the marginal values π_S and π_T by estimating the following log-linear hedonic

$$\ln P_j = \nu_0 + \nu_1 \frac{S_j}{R_j} + \nu_2 \frac{T_j}{N_j} + \sum_{l=1}^{K} \nu_l X_{lj} + \sum_{t=1}^{T} \nu_t Y_t, \tag{6}$$

where R_j is the average subdivision size specific to each city, C; N_j is the number of trails at the closest open space site; and Y_t are year fixed effects. For both open space terms, the relevant measure of open space is obtained using only the nearest open space feature. The marginal values associated with open space size and trail distance are given by

$$\pi_{Sj} = \frac{\widehat{\nu_1} P_j}{R_j}, \pi_{Tj} = \frac{\widehat{\nu_2} P_j}{N_j}. \tag{7}$$

Using the estimated marginal values, we estimate equation (5) and recover the CES parameters using the following two relationships

$$\alpha = e^{\hat{a}}/(1 + e^{\hat{a}})$$
$$\rho = \hat{b} + 1, \tag{8}$$

where $\hat{a}$ is an estimate of the intercept and $\hat{b}$ is the slope coefficient. At this stage, we have everything necessary to form the composite index of open space entering household utility.

To estimate the CES parameters α and ρ, we use data on actual housing transactions from the Phoenix metropolitan area spanning the years 1998 through 2006. Within the Phoenix area, we focus specifically on the upscale Northeast portion of the metropolitan area which contains several large regional parks. This area, along with the regional parks, is shown in figure 2. Information about each of the regional parks shown in figure 2 is provided in table 1. These parks will serve as the basis for quasi-experiments discussed in subsequent sections. The first step of our calibration method recovers the marginal values shown in equation (7) by estimating the first-stage hedonic shown in equation (6).

Results from this hedonic are presented in table 2 along with summary statistics for key variables. All of the housing characteristic coefficients take on the expected sign as do the coefficients for the ratio of park size to neighborhood size as well as the ratio of trail length to number of trails, both of which are positive and significant. The neighborhood size variable we use is the median size of assessor defined subdivisions across each city in the study area.

Using the estimated coefficients, we calculate the marginal values in equation (7) and estimate a linear regression of the form given in equation (5). We then calculate the parameters of the CES function which are shown at the bottom of table 2. In addition, we calculate the elasticity of substitution which has a value of 2.85 indicating that trail length and park size are substitutes for one another. Using these values we are able to calculate the true value of open space as an input into the assignment model presented in the next section.

III. Assignment Model

Following Cropper et al [1988], we use an assignment model to recover a unique equilibrium assignment of households to houses at a specific vector of prices (bids). The structure of the assignment model is formed by specifying the utility a household, i, receives from occupying house j, as

$$v_{ij} = V_i\left(M_i - B_{ji}, A_j, I_i\right), \tag{9}$$

where B_{ji} is the bid household i would make for house j in order to keep utility constant at v_{ij}. A_j are the attributes of house j and I_i are characteristics of the household. A unique assignment equilibrium occurs for the set of utilities $v^* = (v_1^*, v_2^*, \dots v_N^*)$ and prices $P^* = (P_1^*, P_2^*, \dots P_N^*)$ so long as the following conditions are met with $X_{ij} = 1$ if a household i occupies j and $X_{ij} = 0$, otherwise:

$$\begin{aligned} &B_{ji}(v_i^*) = P_j^*, \forall_{ji} \; if \; X_{ij} = 1, \\ &B_{ji}(v_i^*) \leq P_j^*, \forall_{ji} \; if \; X_{ij} = 0, \\ &\sum\nolimits_i X_{ij} = 1 \; \forall_j \,, \\ &\sum\nolimits_j X_{ji} = 1 \; \forall_i . \end{aligned} \tag{10}$$

The first and second conditions ensure that each household pays the maximum they are willing to pay for a house they occupy and no other household is willing to pay more for that house. The last two conditions ensure that each household is assigned a unique house and no house is assigned to more than one household.

In order to generate the assignment equilibrium, an initial set of preference parameters for each household along with a set of unique housing characteristics representing houses must be specified. To construct preference parameters consistent with observed correlation patterns, we employ the Brown and Rosen [1982] algebra to estimate a second stage hedonic using actual housing transaction data from the Phoenix metropolitan area. We specify a Generalized Leontief utility function as shown in equation (1) to recover the preference parameters γ and β_l where we normalize β_0 to unity. The first-stage hedonic results are given in table 3, where the park variable is formed using equation (2) along with the estimated CES parameters. It is important to note that this regression does not consider the perceived value of open space as a composite of size and trails relative to subdivision size and number of trails.

Results from the second stage hedonic are shown in table 4. While these results are likely confounded by endogeneity concerns we are merely using these results to calibrate an assignment model where these preferences are assumed to characterize the "true" model. We could just have easily taken random draws of parameters, but that approach would not preserve potentially important sources of correlation across variables. By calibrating the model using actual data, we are attempting to preserve observed correlation patterns, as well as differences in scale, that one would expect to encounter in real-world applications. Using our estimated preference parameters along with the associated covariance matrix, we take multivariate random normal draws using 10 times the estimated variance to obtain household preference parameters defining unique households entering the assignment model.

The final step of setting up the assignment model is to create a set of houses over which households sort. These houses also characterize the baseline conditions prior to imposing any exogenous changes which form the basis for our quasi-experiments. To create this baseline set of houses, we remove the Spur Cross and McDowell regional parks, leaving a total of four regional parks. As a result of removing those parks, some households in our data sample are no longer near any regional park. We impose a cutoff of 5 miles around each remaining park and assume that houses falling outside that range are no longer near a park. This results in a true open space measure of 0 for those houses as both the size and miles of trails to the nearest park are assumed zero. Using this baseline characterization of the housing market, a sample of 1000 houses is randomly selected. Summary statistics for the sample of 1000 houses are shown in table 4.

IV. Evaluation of reduced form model performance

The quasi-experiments we analyze address three different, yet related concepts of non-marginal changes. The first experiment examines the creation of a new regional park, the second examines changes in the attributes of an existing park, and the third exploits the additive structure of the true open space measure to examine an identical change in that measure, but achieved through different combinations of increasing size and miles of trails. Following the non-market valuation literature using quasi-experiments, we evaluate the models based on comparing houses before the exogenous change to the identical houses after the exogenous change. An alternative to this approach is to match individuals as they move to different houses, but due to lack of data tracking the same individual across time, this approach has not been undertaken in the existing literature on non-market valuation. For further discussion of this alternative approach, see Klaiber and Smith [2009].

To measure the true willingness to pay for changes in the open space amenity, we use the known structure of utility along with the known preference parameters of households to calculate willingness to pay for each household. We assume that the exogenous changes are large enough to result in re-sorting across households, but not large enough to change income. With these assumptions, define the utility received by a household prior to the change as

$$U_0 = \gamma O_0^{\frac{1}{2}} + \beta_0 (M - P_o)^{\frac{1}{2}} + \sum_{l=1}^{K} \beta_l X_{lj}^{\frac{1}{2}}, \tag{11}$$

where the zero subscript indicates before the change. Similarly, define the utility level following a change using a one subscript as

$$U_1 = \gamma O_1^{\frac{1}{2}} + \beta_0 (M - P_0 - WTP)^{\frac{1}{2}} + \sum_{l=1}^{K} \beta_l X_{lj}^{\frac{1}{2}}. \tag{12}$$

Equating $U_0 = U_1$ and rearranging, we can recover the general equilibrium willingness to pay for a change in open space as

$$WTP = -2\gamma\left[O_0^{\frac{1}{2}} - O_1^{\frac{1}{2}}\right](M - P_0)^{\frac{1}{2}} - \gamma^2\left[O_0^{\frac{1}{2}} - O_1^{\frac{1}{2}}\right]^2. \quad (13)$$

The definition of this willingness to pay measure is defined in terms of the household occupying each house after the exogenous treatment.

As a comparison to the true willingness to pay, cross-sectional hedonic estimates as well as hedonic difference estimates of willingness to pay are calculated for both linear and semi-log specifications. The cross sectional hedonic models are estimated using the prices and characteristics of houses following the change to estimate marginal values associated with the relative open space measures of park size to subdivision size and miles of trails to number of trails. For the difference models, changes in housing characteristics drop out as a result of matching by household leaving only changes in the relative measures of open space as regressors for the dependent variable formed by differencing housing prices before and after the exogenous change.

In addition to the reduced form structure, a final consideration in comparing willingness to pay measures concerns which sample of houses to evaluate. As the exogenous change directly impacts a small subset of the total number of houses, two potential samples of houses over which model performance is judged emerge. The first sample averages over all houses in the sample, regardless of whether a house experienced the treatment. This sample not only includes the direct effect of open space changes on housing prices, but also accounts for the general equilibrium price changes for all houses in the market. The price changes for houses not directly impacted by the policy are significantly smaller than those for houses directly impacted resulting in an average willingness to pay that is smaller than that associated with only the impacted houses. The second sample considers only the houses experiencing a direct change as a result of the treatment. As the policy change directly influences only a small number of houses in the market, this sample is considerably smaller than the full sample. Willingness to pay estimates using each sample are reported for each experiment along with the number of houses included in each sample.

A. Adding a new park

The first experiment we consider adds a new park where previously no park existed. For this experiment, we consider two different variations that impact different numbers of houses. Both variants add the identical McDowell Preserve but choose different locations for the park. In the first case, the preserve is added to its actual location and becomes the closest park to 55 houses. In the second case, the preserve is added in the Spur Cross location and only becomes the closest park to 3 houses. In addition to the different number of houses impacted, the difference between the two locations results in a different normalizing scale in the reduced form estimating equations because the impacted houses fall in subdivision located in different cities. Results from this experiment are shown in table 5.

Focusing first on the difference in mean willingness to pay across the entire sample, the WTP is considerably higher for the addition of the park located in the actual McDowell location compared with the addition in the Spur Cross location as more households receive the added amenity of the new park. In terms of model performance, the cross sectional models perform better for the McDowell location than the Spur Cross location with errors of 5% or less for McDowell and near 30% for the Spur Cross location. The performance is reversed when examining the difference models with the Spur Cross location having errors of around 3% compared to over 8% for the McDowell location. Overall, for the full sample of houses the difference models appear to provide the best fit, likely as a result of their better ability to account for the relative changes in subdivision size.

Examining only the houses directly impacted by the policy, the cross sectional models perform poorly in both the Spur Cross and the McDowell location with errors of at least 20%. In contrast, the worst performing difference models are associated with the McDowell location and have errors of 16% and 10% for linear and semi-log specifications, respectively. For the much smaller Spur Cross location, the difference models only have errors of around 3%. This difference suggests that the extent of the impact from an exogenous change is an important element in defining what differentiates a marginal from non-marginal change.

Overall, it appears that when focusing on the number of impacted houses as a measure of "big," the selection of the sample is very important. There was no clear difference in performance across the entire sample between adding a new park that impacted a large number of hoses and adding a new park that impacted only a small number of houses. In contrast, focusing only on the sample consisting of impacted houses, the role of size is much more evident. This experiment also highlights the important role of perceptions captured in the reduced form model. The difference model appears better suited to capturing the impact of these normalizations, particularly when focused only on the houses directly impacted by the policy

B. Increasing park size

The second set of experiments examine increases in the size of parks and report the results for three simulated experiments in table 6. For the first experiment, the very small Black Mountain Park was increased in size by 10%. For comparison, the second experiment focus on the much larger Reach 11 park which is also increased in size by 10%, representing a much larger change in acreage. Comparing the two quasi-experiments, there is little difference in performance across the cross-sectional models, while the difference models perform substantially better for the smaller absolute change in the Black Mountain Park. Using only the subset of houses impacted by the change, there once again is not a clear difference in performance, although model performance for the Reach 11 park change may hold a slight edge. Overall, for the identical percentage change in two different parks, there does not appear to be a significant difference in performance depending on the size of the park.

The third element of this comparison involves increasing the size of the Reach 11 Park by 40% and compares that change with the smaller increase of 10% discussed above. This comparison keeps the number of households impacted the same as well as the impact of normalizing park size by the size of subdivisions. As with the previous comparison, there does not appear to be a clear difference in performance across the two experiments even though the magnitude of the change in size is 30% greater in the third scenario compared to the previous scenario.

C. Identical changes to composite measure of open space

The third series of quasi-experiments focuses on a 10% increase in the "true" measure of open space, but achieves this increase in three different ways. In all cases, the Cave Creek Park is expanded by 10%. This park is fairly small, impacting less than 4% of the total number of houses in the market. For the first case, the 10% increase is achieved using only changes in the miles of trails, the second case only changes the size of the park, and the third case increases the value of the park with a 5% increase coming from increases in trail length and a 5% increase from changes in park size. Results are reported in table 7.

Regardless of focusing on the entire sample or the subsample directly impacted by the change, the cross sectional models are preferred in the case of an increase to park size while the difference models are preferred in the case of an increase in trail length. As park size is perceived relative to subdivision size, this measure provides more variation than trail length which is relative to the number of trails and thereby fixed across all households. The increase in heterogeneity caused by the relative nature of park size is one potential explanation for the superior performance of cross sectional models where the change is strictly in park size.

For the difference models, an opposite effect is found with the experiment only changing trail length, which is perceived relative to the total number of trails, performing better than the cross sectional models. As with the performance of the cross-sectional models, this result likely indicates that the role of perceptions play an important role in determining reduced form model performance. This series of experiments has demonstrated that differences in the perception of the non-market amenity as expressed in the reduced form model can result in large differences in model performance depending on the type of normalization imposed

V. Conclusions

This paper presents a utility framework used to examine two important, yet understudied issues involved in the quasi-experimental literature. The first issue addresses model performance when non-marginal changes are the focus of the exogenous treatment. The second issue recognizes that the perception of a non-market good is often different from the way the good actually enters an agent's utility function. To address each of these issues, an assignment model is calibrated and a series of controlled experiments are performed. The use of an assignment model provides the ability to solve for new equilibria following exogenous changes. By knowing the actual preferences of households, the extent of the exogenous changes, and housing characteristics; the assignment model allows us to calculate the "true" willingness to pay for an exogenous change. This true willingness to pay is compared to estimated willingness to pay measures arising from a variety of reduced form models.

Three different types of quasi-experiments are examined and together they show that willingness to pay estimates are very sensitive to different specifications, particularly when the normalizing factors are different. While there is some difference between linear and semi-log functional forms, the largest differences in model performance are apparent between cross-sectional and difference specifications. We hypothesize that this difference is a result of the perceived nature of open space as represented in the reduced form estimating models. We examine two components of open space including relative size and relative trail length. The size component varies depending on the average subdivision size of the city in which a house is located. The trail length varies only across parks by the number of trails, creating in effect an average trail length variable. The cross-sectional models appear better suited to handling large changes in size while the difference models perform better with changes to trails, where the normalizing factor is constant across all houses.

In terms of defining what constitutes a large change, we found mixed results. The performance of quasi-experimental models differs considerably depending on the subset of houses under examination. When examining the entire sample, it was not clear that the scenarios examined provided significant insight into the nature of non-marginal changes. In contrast, when examining only the subset of houses directly impacted by an exogenous treatment, we did find evidence of model deterioration as changes became larger, particularly when the number of impacted households increased. For the case of adding a new park, the difference models performed significantly worse when the added park impacted more houses. The opposite effect was found when increasing the size of an existing park with the cross sectional models performing worse as the magnitude of the change increased. This difference once again suggests that perceptions captured in reduced form modeling play an important role.

Future work extending the initial work presented in this paper should attempt to further refine the quasi-experiments under evaluation and further explore the role of perceptions in reduced form modeling. To date, little attention has been paid to the perception of amenities in reduced form modeling and we believe this work highlights the large role these contribute to model performance. Further understanding how these perceptions based normalizations influence model performance would aid in future quasi-experimental applications.

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Table 1. Park Information

Park Name	# Households	% Households	Park Value	Size (acres)	Trail Distance	# Trails
Cave Buttes	57,729	28.18%	1.02	2817	0.25	1
Black Mountain	6,765	3.30%	1.19	246	1.1	1
Spur Cross	867	0.42%	7.86	2154	7	5
Cave Creek	17,223	8.41%	12.12	2938	11	6
Reach 11	102,401	49.99%	17.79	1524	18	5
McDowell Preserve	19,866	9.70%	58.95	21087	50	18

Table 2: CES calibration first-stage hedonic

	Hedonic Estimates			Summary Statistics			
Variable	Estimate	Std Err	t-stat	Mean	Std Dev	Min	Max
Constant / Price[a]	8.4023	0.0077	1093.11	29605	18616	1870	198550
Square feet (100s)	0.0782	0.0004	179.59	21.04	7.69	6.00	60.00
Acres	0.2627	0.0038	69.46	0.27	0.32	0.05	13.94
Stories	-0.1908	0.0018	-103.59	1.18	0.38	1.00	4.00
Bathrooms	0.1115	0.0015	72.01	2.83	0.87	0.70	6.00
Age	-0.0067	0.0002	-38.96	14.36	13.28	1.00	84.00
Pool	0.0730	0.0014	52.31	0.46	0.50	0.00	1.00
Garage	0.0508	0.0031	16.40	0.95	0.21	0.00	1.00
CBD distance	0.0001	0.0002	0.34	16.93	5.47	5.43	34.64
Size / Nbhd Size	0.0001	0.0000	62.52	359.93	555.40	10.25	2783.39
Trail Dist / Trails	0.0509	0.0005	101.82	2.34	1.46	0.25	3.60
Age^2	0.0000	0.0000	9.50				
$Sqft (100s)^2$	-0.0008	0.0000	-105.12				
$Acres^2$	-0.0305	0.0010	-30.41				
Year Dummy Variables							
1998	-0.1638	0.0027	-59.74				
1999	-0.0835	0.0027	-30.66				
2000		Omitted					
2001	0.0532	0.0029	18.64				
2002	0.0982	0.0028	34.80				
2003	0.1819	0.0028	65.93				
2004	0.3078	0.0027	115.94				
2005	0.5936	0.0027	220.61				
2006	0.7257	0.0030	240.18				
Statistics							
# Observations	204,851						
Adjusted R^2	0.7576						
Alpha parameer	0.0730						
Rho parameter	0.6497						
Elasticity of sub	2.8545						

[b]Price is based on 11% of sale value and corresponds to summary statitics

Table 3: Two-Stage hedonic preference calibration

	First-Stage Hedonic			Second Stage Hedonic		
Variable	Estimate	Std Err	t-stat	Estimate	Std Err	t-stat
Constant	8.9483	0.0064	1401.40			
Square feet (100s)	0.0364	0.0002	215.84	27.3390	0.1584	172.60
Acres	0.1604	0.0023	68.71	1.0901	0.0074	147.69
Stories	-0.1860	0.0019	-98.56	-5.3937	0.0191	-282.22
Bathrooms	0.1170	0.0016	73.04	3.7916	0.0190	199.77
Age	-0.0053	0.0001	-64.19	-0.2045	0.0015	-134.27
Pool	0.0969	0.0014	68.56	2.5047	0.0111	226.17
Garage	0.0490	0.0032	15.44	1.9331	0.0065	299.00
CBD distance	-0.0016	0.0002	-9.27	-0.1724	0.0007	-256.78
Park	0.0049	0.0000	116.99	0.0962	0.0014	68.27
Year Dummy Variables						
1998	-0.1601	0.0028	-56.44			
1999	-0.0841	0.0028	-29.84			
2000		Omitted				
2001	0.0525	0.0030	17.79			
2002	0.0977	0.0029	33.50			
2003	0.1818	0.0029	63.76			
2004	0.3095	0.0027	112.92			
2005	0.5956	0.0028	214.53			
2006	0.7252	0.0031	232.50			
Statistics						
# Observations	204,851					
Adjusted R^2	0.7406					

Table 4. Baseline 1,000 housing sample characteristics

Characteristic	Mean	Std Dev	Min	Max
Square feet (100s)	22.00	8.27	8.06	54.56
Acres	0.29	0.36	0.06	5.19
Stories	1.20	0.40	1.00	2.00
Bathrooms	2.89	0.93	1.00	6.00
Age	14.42	13.79	1.00	75.00
Pool	0.48	0.50	0.00	1.00
Garage	0.95	0.21	0.00	1.00
CBD distance	16.74	5.61	5.43	31.86
Park	29.59	30.94	0.00	81.73

Table 5. Quasi-experiment creating a new park

			Estimated WTP				
Add McDowell in McDowell Location							
Model	Sample Size	Specification	Mean	Std Dev	Min	Max	% Error
True WTP	1000		48.26	170.23	-343.47	1146.10	0.0%
Cross Sectional	1000	Linear	48.87	206.41	0.00	1504.59	1.3%
Cross Sectional	1000	Log-Linear	45.75	199.25	0.00	1340.82	-5.2%
Difference	1000	Linear	44.18	189.61	0.00	1369.03	-8.5%
Difference	1000	Log-Linear	42.08	181.95	0.00	1207.28	-12.8%
True WTP	55		691.30	155.89	476.64	1146.10	0.0%
Cross Sectional	55	Linear	888.48	168.57	712.63	1504.59	28.5%
Cross Sectional	55	Log-Linear	831.89	261.44	437.74	1340.82	20.3%
Difference	55	Linear	803.22	210.14	543.62	1369.03	16.2%
Difference	55	Log-Linear	765.17	221.25	429.78	1207.28	10.7%
Add McDowell in Spur Cross Location							
True WTP	1000		1.99	36.90	-296.80	730.28	0.0%
Cross Sectional	1000	Linear	2.56	46.89	0.00	951.30	29.0%
Cross Sectional	1000	Log-Linear	2.68	49.39	0.00	1071.54	35.0%
Difference	1000	Linear	1.93	35.33	0.00	703.29	-2.7%
Difference	1000	Log-Linear	1.92	35.41	0.00	711.16	-3.1%
True WTP	3		624.27	92.83	557.53	730.28	0.0%
Cross Sectional	3	Linear	854.11	84.17	804.62	951.30	36.8%
Cross Sectional	3	Log-Linear	893.83	154.03	798.61	1071.54	43.2%
Difference	3	Linear	644.28	51.11	614.05	703.29	3.2%
Difference	3	Log-Linear	641.30	106.82	518.34	711.16	2.7%

Table 6. Quasi-experiment increasing park size

10% Increase to Black Mountain (Small Park)							
			Estimated WTP				
Model	Sample Size	Specification	Mean	Std Dev	Min	Max	% Error
True WTP	1000		0.55	28.69	-314.28	284.01	0.0%
Cross Sectional	1000	Linear	0.24	1.19	0.00	6.33	-56.2%
Cross Sectional	1000	Log-Linear	0.26	1.28	0.00	10.66	-53.8%
Difference	1000	Linear	0.52	2.55	0.00	13.63	-5.7%
Difference	1000	Log-Linear	0.47	2.34	0.00	19.49	-15.6%
True WTP	41		11.51	64.63	-279.81	126.01	0.0%
Cross Sectional	41	Linear	5.91	0.90	3.34	6.33	-48.7%
Cross Sectional	41	Log-Linear	6.23	1.68	3.69	10.66	-45.9%
Difference	41	Linear	12.72	1.93	7.19	13.63	10.5%
Difference	41	Log-Linear	11.38	3.06	6.75	19.49	-1.1%
10% Increase to Reach 11 (Large Park)							
True WTP	1000		1.78	20.82	-280.56	289.38	0.0%
Cross Sectional	1000	Linear	2.78	3.86	0.00	8.74	56.4%
Cross Sectional	1000	Log-Linear	2.44	3.45	0.00	12.82	37.4%
Difference	1000	Linear	2.20	3.06	0.00	6.94	24.1%
Difference	1000	Log-Linear	2.96	4.18	0.00	15.55	66.7%
True WTP	348		6.92	21.36	3.05	289.38	0.0%
Cross Sectional	348	Linear	7.98	1.12	6.33	8.74	15.2%
Cross Sectional	348	Log-Linear	7.01	1.44	4.50	12.82	1.3%
Difference	348	Linear	6.33	0.89	5.03	6.94	-8.5%
Difference	348	Log-Linear	8.50	1.75	5.46	15.55	22.9%
40% Increase to Reach 11							
True WTP	1000		15.98	49.03	-343.47	373.86	0.0%
Cross Sectional	1000	Linear	26.35	36.62	0.00	82.92	64.8%
Cross Sectional	1000	Log-Linear	23.37	33.01	0.00	122.62	46.2%
Difference	1000	Linear	16.92	23.52	0.00	53.25	5.9%
Difference	1000	Log-Linear	19.95	28.18	0.00	104.67	24.8%
True WTP	348		47.64	26.99	5.76	322.70	0.0%
Cross Sectional	348	Linear	75.71	10.63	60.10	82.92	58.9%
Cross Sectional	348	Log-Linear	67.16	13.74	43.14	122.62	41.0%
Difference	348	Linear	48.62	6.82	38.59	53.25	2.1%
Difference	348	Log-Linear	57.33	11.73	36.82	104.67	20.4%

Table 7. Quasi-experiment creating 10% increase in Cave Creek park

Model	Sample Size	Specification	Mean	Std Dev	Min	Max	% Error
			Trail Only				
			Estimated WTP				
Model	Sample Size	Specification	Mean	Std Dev	Min	Max	% Error
True WTP	1000		0.62	25.98	-314.28	275.81	0.0%
Cross Sectional	1000	Linear	1.20	6.12	0.00	32.38	92.1%
Cross Sectional	1000	Log-Linear	1.16	6.03	0.00	46.68	86.3%
Difference	1000	Linear	0.63	3.20	0.00	16.94	0.5%
Difference	1000	Log-Linear	0.62	3.22	0.00	24.93	-0.5%
True WTP	37		21.75	17.78	10.25	107.55	0.0%
Cross Sectional	37	Linear	32.38	0.00	32.38	32.38	48.9%
Cross Sectional	37	Log-Linear	31.41	5.62	20.75	46.68	44.4%
Difference	37	Linear	16.94	0.00	16.94	16.94	-22.1%
Difference	37	Log-Linear	16.77	3.00	11.08	24.93	-22.9%
			Size Only				
True WTP	1000		0.62	25.98	-314.28	275.81	0.0%
Cross Sectional	1000	Linear	1.02	5.46	0.00	34.53	63.9%
Cross Sectional	1000	Log-Linear	1.01	5.52	0.00	50.35	62.4%
Difference	1000	Linear	0.58	3.08	0.00	19.45	-7.7%
Difference	1000	Log-Linear	0.57	3.10	0.00	28.23	-9.0%
True WTP	37		21.75	17.78	10.25	107.55	0.0%
Cross Sectional	37	Linear	27.62	8.48	17.49	34.53	27.0%
Cross Sectional	37	Log-Linear	27.37	10.27	11.34	50.35	25.8%
Difference	37	Linear	15.56	4.78	9.86	19.45	-28.4%
Difference	37	Log-Linear	15.35	5.76	6.36	28.23	-29.4%
			Half Trails, Half Size				
True WTP	1000		0.63	25.99	-314.28	275.81	0.0%
Cross Sectional	1000	Linear	1.09	5.61	0.00	32.81	72.9%
Cross Sectional	1000	Log-Linear	1.06	5.58	0.00	47.42	68.9%
Difference	1000	Linear	0.53	2.70	0.00	15.58	-16.2%
Difference	1000	Log-Linear	0.30	1.74	0.00	18.02	-51.9%
True WTP	37		21.89	17.79	10.34	107.72	0.0%
Cross Sectional	37	Linear	29.40	4.20	24.38	32.81	34.3%
Cross Sectional	37	Log-Linear	28.71	7.03	15.66	47.42	31.1%
Difference	37	Linear	14.25	1.11	13.34	15.58	-34.9%
Difference	37	Log-Linear	8.17	4.26	3.67	18.02	-62.7%

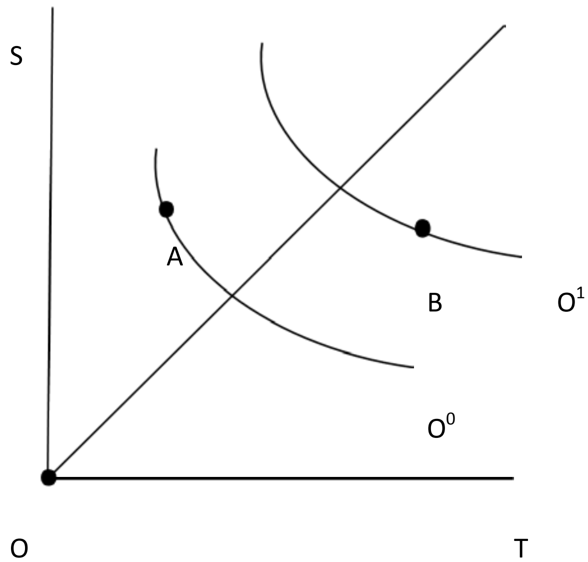

Figure 1. Open space

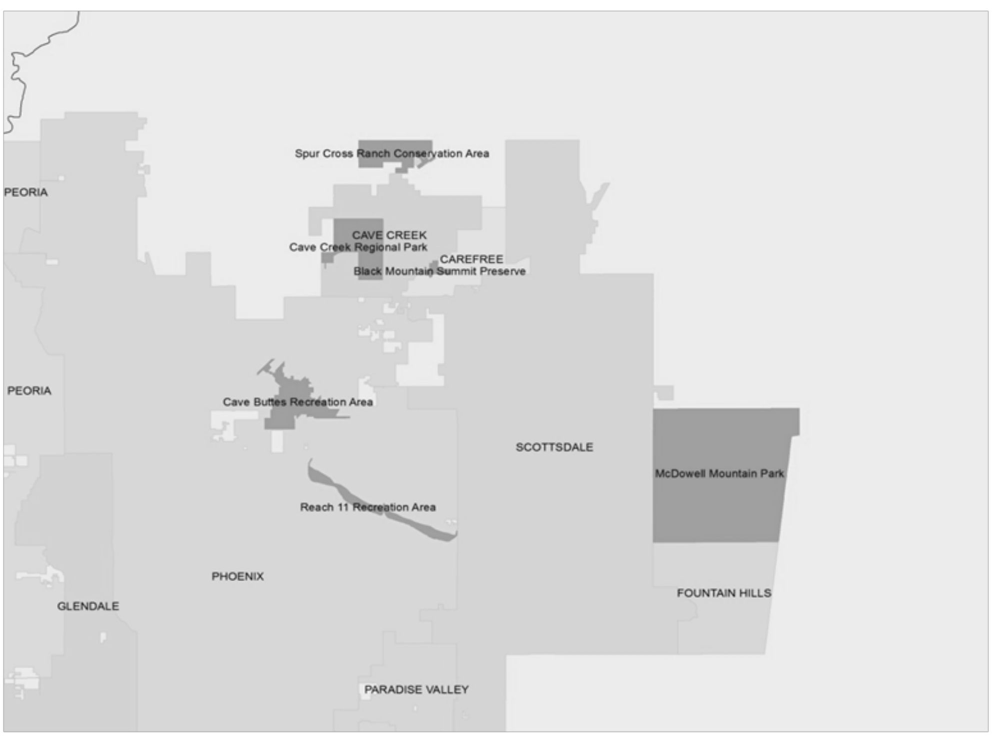

Figure 2. Location of regional parks