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ABSTRACT

This paper uses the 2011 Phoenix Area Social Survey to evaluate the plausibility of the assumptions made by locational equilibrium sorting models to rationalize incomplete stratification of households across local communities by income. The analysis with a well-recognized index of environmental attitudes, the New Environmental Paradigm (NEP), confirms the correlations in equilibrium outcomes implied by these models. As a result, it supports the role of differences in the tastes for public goods as an explanation for the sorting outcomes.

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1. Introduction

The first generation of multi-community, equilibrium sorting models assumed households varied along a single dimension, usually income. When used to describe how those agents sort among communities, based on housing prices and local public goods, they predicted too much stratification by income.[1] Fifteen years ago, Epple and Platt [1998] introduced an extension to the model where households differed in income and in their tastes for local public goods. In the Epple-Platt framework there can be several communities with differing levels of public goods and residents that have the same income, implying incomplete stratification. About the same time, Epple and Sieg [1999] described how combining measures of the differences in income distributions across communities with information about housing prices and local public goods allows the same logic to be used in estimating household preferences for local public goods. Their insight has led to a rich literature (see Kuminoff et. al. [2013]). All of these studies using the pure characteristics model rely on the maintained assumption that unobserved heterogeneity in households' tastes for public goods rationalizes incomplete stratification. To date there has not been an independent confirmation of the plausibility of this maintained assumption.

This paper uses data collected as part of the activities of the Central Arizona Project's Long Term Ecological Research (CAP-LTER) site to evaluate whether a well-recognized index of environmental attitudes, the New Environmental Paradigm (NEP),[2] is consistent with the outcomes assumed in sorting models. To our knowledge, this application is the first use of the NEP in a revealed preference analysis of household choices involving public goods. Our findings confirm the key linkages using correlations between the averages (across survey respondents) of the NEP, income, and community specific price indexes as "aggregators" of the influence of

[1]This strategy was first proposed by Ellickson [1971] and has been a part of equilibrium models of multi-community models for the determination of taxes and public good ever since.

[2] The attitude index has also been labeled the New Ecological Paradigm. The attitude measure has evolved since it was originally proposed by Dunlap and Van Liere [1978] thirty-five years ago. See Harcroft and Milfont [2010] for a summary and analysis.

local public goods. The analysis adopts a definition for the spatial scale of neighborhoods that is consistent with what is used with sorting models. Overall, our findings provide clear support for the Epple-Platt logic.

Section two reviews the basic elements of the pure characteristics model. Section three describes the structure of the survey that collected the information used to construct the NEP scale. Section four summarizes estimates for the Sieg et al [2002] housing price index and provides our primary results.

2. Sorting Models

Locational sorting models stem from Charles Tiebout's [1956] classic paper arguing that when the amount of local public goods varies by community, each household can select its preferred amount of these goods by choosing a community. This logic assumes the private housing alternatives and other private goods and services are approximately comparable across communities. It also usually ignores the potential constraints to these decisions implied by the labor market choices of working households and moving costs. For our purpose here we will abstract from recent generalizations and summarize the key features of a simple, pure characteristics model[3].

Assume that in a given area, there are a set of neighborhoods. In empirical studies these neighborhoods are usually defined as school districts or census tracts. Each house is represented as a set of characteristics as well as a set of local public services and amenities conveyed by the home's location in one of these neighborhoods. Equation (1) specifies a household's (i) objective function with utility determined by consumption of housing services, h_k, at a location k; a composite numeraire, private good, Z_i; local public goods and amenities, g_j that vary with

[3] These issues are areas of current research. For example, Kuminoff [2010] has extended the framework to treat a choice as a community/job location pair.

neighborhood, j; the unobservable taste index, α_i which is our focus here; and demographic features of the household, d_i.

The budget constraint, also in (1), has income, m_i, the price of housing $P_{k\in j}$ (i.e. P with the subscript $k \in j$ means the annualized price of house k in community j) and the price of the numeraire good normalized to unity.

$$(1) \qquad \underset{k \in j, \mathrm{Z}}{\text{Max}}\ U(\mathrm{Z}_i, h_k, g_j; \alpha_{i,} d_i)$$

$$m_i = \mathrm{Z}_i + P_{k\in j}$$

Households have full information and there are no moving costs. The solution to this choice problem is described with an indirect utility function, which is the usual starting part for most empirical sorting models. The maintained properties of the function are what distinguish the pure characteristics and random utility versions of the model.

Two features of the pure characteristics model are important to our objective. First, all households are assumed to evaluate local public goods and amenities in the same way. The unobserved taste parameter provides this "explanation" for why those with the same income do not select the same location. The second feature is the single crossing condition. This assumption implies the slope of an indifference curve defined in terms of the arguments of the indirect utility function, $v(.)$, in (g, P) space increases monotonically with both income (m) and with the unobserved taste parameter, α, as in equation (2).

$$(2) \qquad \frac{\partial}{\partial m}\left(\frac{dP}{dg}\Big|_{v = \bar{v}}\right) > 0$$

$$\frac{\partial}{\partial \alpha}\left(\frac{dP}{dg}\Big|_{v = \bar{v}}\right) > 0$$

This property implies that the equilibrium distribution of households will have specific features for any two neighborhoods. Conditional on stratification by income (for given tastes) the

equilibrium yields a link between neighborhood prices and the index of local public goods. More specifically, if we order the neighborhoods by the equilibrium price of each location, then the index of local public goods and amenities will have the same ordering. This outcome is defined formally in equation (3).

$$(3) \qquad m_{j+1}(\alpha) > m_j(\alpha) \Longrightarrow P_{j+1} > P_j \text{ and } g_{j+1} > g_j$$

The second part of the equilibrium is stratification by income given α and stratification by α given income. These features imply we should observe correlations between measures of household preferences for public goods and income, controlling for either all of the local public goods or the price index across neighborhoods. The price index and index of public goods are linked by the equilibrium. All of these expectations relate to neighborhood level averages for each of the variables.

3. The New Environmental Paradigm

The NSF sponsored CAP-LTER conducts a periodic social survey linked to the neighborhoods that are also sampled to evaluate local ecological indicators. Our analysis is primarily based on the most recent of these surveys – the 2011 Phoenix Area Social Survey (PASS). The design of the PASS survey selects neighborhoods to match the ecological monitoring sites in the CAP-LTER study area. These monitors study vegetation, soil, and other ecological variables on 30 x 30 meter sample plots distributed over all types of land uses in the study area (see Grimm and Redman [2004]). The land use classifications lead to 204 long-term monitoring sites in the study area. The initial set of neighborhoods used in the 2011 Phoenix Area Social Survey follows the protocol defined for the first social survey conducted in 2006 with neighborhoods selected after examining aerial photographs of the areas surrounding 101 of

the monitoring sites[4]. Figure 1 provides a map of the area that identifies the sampled neighborhoods.

An important consideration in the survey design was assuring the monitoring data could be linked to the survey responses. After overlaying the remaining 94 sites (101 in residential areas less the seven eliminated sites, see note #4) with Census block groups, the Census income information was used to define groups based on income and location. Eight groups were specified, including: low income Phoenix core; low income suburban; middle to high income Phoenix core; middle income suburban; low to middle income fringe areas; high income suburban; high income fringe; and retirement communities. Five neighborhoods were selected from each group to reflect the demographic composition, the mix of owners and renters, as well as, to matching the monitoring data. This strategy defined 40 neighborhoods. In 2011, five new neighborhoods were added.

The PASS survey was administered by the Institute for Social Science Research at Arizona State University from May 26, 2011 to January 6, 2012. The target population was heads of households aged 18 or older who lived in one of the 45 neighborhoods. 806 completed surveys for a minimum response rate of 43.4 percent.[5]

NEP relies on the maintained hypothesis that multiple item indexes provide a more reliable gauge of attributes than single item questions. Five dimensions of environmental attitudes can be identified in the questions, including: the reality of limits to growth; anti-anthropocentrism; the fragility of nature's balance; sentiments that reflect a rejection of the idea

[4] Seven sites of the sixteen visited were eliminated because the residents were not close to the plot used for monitoring.

[5] The minimum response rate is the number of complete interviews divided by the number of interviews (complete plus partial) plus the number of non-interviews (refusal and break-off plus non-contacts plus others) plus all cases of unknown eligibility.

that humans are exempt from the constraints of nature; and the possibility of an ecological catastrophe.[6]

The index is derived from 15 Likert scale (five points) questions. Response categories for each item are "strongly agree", "somewhat agree", "unsure", "somewhat disagree", and "strongly disagree." As Clark et al. [2003] explain, before combining the items into a single index it is desirable to check for the internal consistency of the responses. We follow their strategy in developing this assessment and use variations on their three indicators – the simple correlation between each item's response and overall NEP index, Cronbach's alpha coefficient to gauge the level of reliability of a single scale summarizing the expressed attitudes, and, finally, using the item responses to develop a factor analysis, we consider the size of the first factor loading and its contribution to the variance associated with this factor.

Table 1 summarizes the 15 questions in the NEP coded so the 1 to 5 scores are consistent with the way ratings contribute to the NEP. This format implies the questions where "strongly disagree" would be consistent with a high attitude level for environmental objectives were coded as 5. Similarly, questions where "strongly agree" would be consistent with a high attitude level for environmental objectives were coded as 5. That table reports the percentage of respondents providing the score 1 to 5 for each item and the number of respondents answering the question. Measures for the other three gauges of consistency are also reported in the table. The simple correlations with NEP range from .32 to .66. Cronbach's alpha, measured as the square of the correlation between the measured scale (the sum of the item scores) and the first factor from a factor analysis. Our estimate for alpha is .796 which is larger than what Clark et al report and consistent with using NEP at the neighborhood level as a gauge of environmental attitudes. The factor loadings for each question in the NEP index for the first factor range from .20 to .62 across

[6] This summary is based on Kotchen and Reiling's [2000] description of the rationale for the current NEP questions.

the items. The first factor accounts for 80 percent of the variance among items, suggesting a single index of attitudes offers a reasonable summary of these attitudes. Thus, the 2011 PASS survey yields a consistent basis for using the NEP as a single index for environmental attitudes.

4. NEP, Neighborhood Prices, and Local Public Goods

We follow Sieg et al. [2002] method for estimating neighborhood specific price indexes, using housing sales from 1995 to 2008 in 39 of the 45 PASS neighborhoods (the omitted six did not have sufficient housing sales to be included).[7] These sales take place before the PASS survey was undertaken. A semi-log function (in the housing price), specified to include square feet of living space, number of stories, bathrooms, age of the home, presence of garage, pool, number of rooms, and lot size, along with sale year fixed effects and community fixed effects, was estimated with 20,373 observations for the sales transactions in the PASS neighborhoods.[8] Table 2 presents a summary of our findings combining the price indexes with the average value of the NEP, average reported (on the 2011 PASS survey) 2010 income (before taxes), and measures for some of the local public goods that might be considered by households in making their neighborhood choices. Each of the models specifies the NEP as the dependent variable. They vary in the specification of different set of independent variables. Ideally, we would like a full delineation of all the local public goods. This detailed record would be important for estimating a structural model with these data. As noted at the outset, the neighborhood price index, in equilibrium, should reflect all the public goods, amenities, and dis-amenities conveyed by a location. Thus, for our purposes it provides an ideal aggregator of their influence. Nonetheless to illustrate why recognition of the sorting equilibrium is important to understanding the NEP/

[7] See Klaiber and Smith [2012] for a complete description of the sources for the sales housing data. They are developed combining Data Quick transactions records with Maricopa Assessor data. The sources for the test score data are also documented in Klaiber and Smith. In that application the scores relate to elementary grades.
[8] We also investigated the effects of reducing the sample sale to 2007, due to the housing downturn in Phoenix and this did not affect our conclusion.

income relationship, we start by considering the influence of two measures for local public goods often included in sorting models used in public and environmental applications.

Column (1) and (2) illustrate how sorting requires the model to take account of the local public goods to establish a link with the neighborhood averages for the preference index and income. In column (1) we consider income alone and the results would imply no relationship between NEP and income. Once average measures for air quality and the quality of local schools are included, income appears to be correlated with the average NEP as we expected[9]. Our two measures of local public goods are: (1) test scores for junior high schools matched to each neighborhood. This variable was constructed by linking the school districts to the associated Census Block Groups for each PASS neighborhood (see note #7) and (2) EPA's Air Quality Index (AQI) readings associated with each neighborhood.[10] The AQI has the expected negative effect on NEP. Higher levels of the AQI are associated with lower air quality. The results for education are more difficult to rationalize but could reflect the fact that households are not restricted to sending their children to schools in their attendance zone when they provide transportation. They could also reflect our failure to measure all the relevant neighborhood specific public goods and dis-amenities.

[9] The direction of the association is not what we would have expected based on the estimates in the literature. Sieg et.al. [2004], Walsh [2007] and Klaiber and Smith [2012] all found negative correlations in their estimates of pure characteristics sorting models. They were -0.29 to -0.19 for the first study, -0.02 for Walsh, and -0.28 for Klaiber and Smith.

[10] The education is the arithmetic mean of test scores in reading and math for 2003-2007 for grades 7, 8 and 9. The scores are matched using the property IDs for each house in the school district with the scores. The houses are then matched to the PASS neighborhoods and the average reflects a weighted average of the houses associated with each district that are in a PASS neighborhood. The process used for the AQI was somewhat different because the number of monitors was more limited and the records were averages of the daily readings from December 8, 2010 to December 8, 2011 for the PASS neighborhoods that could be matched with the closest monitor. Maricopa County contains 23 air monitoring stations. During this period some stations were closed or not provided by the online data. We considered both particulates (PM10) and the AQI. Monitoring stations identified as: Buckeye, Central Phoenix, Durango, Dysart, Glendale, Greenwood, Mesa, North Phoenix, South Phoenix, South Scottsdale, West 43rd, West Chandler, West Phoenix, Zuni Hills were considered in establishing our matching to PASS neighborhoods. The findings are comparable, so the AQI results were reported here.

In a static sorting model, the average preference index and average income would be jointly determined along with the equilibrium prices. Since our objective is to examine correlations between these jointly determined outcomes recognizing the effects of conditioning variables, the most direct test of the sorting framework is given in column (3) [11]. This specification uses the Sieg et. al. price index for each location to capture the effects of *all* local public goods. As a result, we don't include the AQI and education measures. Now the effect of average income on NEP is negative and statistically significant. That is, the average index for environmental attitudes in a neighborhood, in equilibrium, is negatively correlated with average incomes, as observed in the structural estimates for pure characteristics specifications for sorting models (see note# 8). The structure of the model accounts for the link between local public goods thru the price index for locations. Perfect stratification by income is avoided because of taste differences and their relationship with income.

The remaining columns consider the sensitivity of the findings to different definitions for the environmental index. Columns (4) and (5) use Kotchen and Moore [2007] version for the index based on five questions (labeled NEP1 and identified with an asterisk alongside the questions in Table 1). While the estimates are not as clear-cut as with the full NEP (based on the 15 questions), the signs of the partial effects are comparable.

Finally, in the last column we consider the persistence of the effects of sorting. It is possible to construct a version of the NEP using four questions from the 2006 version of PASS for 40 of the 45 neighborhoods. This is labeled NEP2 (and identified with a "b" alongside the questions in Table 1). We developed this index using the 2011 responses and the 2006 responses

[11] A partial regression coefficient between any two variables measures the correlation between those two variables after the linear effect of other variables have been removed. Our test should focus on the partial correlation between average NEP and average income after the effects of local public goods have been removed. This can be accomplished using the price index as the "aggregator" for all local public goods that can be measured and those that cannot. By the Frisch-Waugh-Lovell theorem the coefficient on income in a regression model for NEP that includes the price along with income provides this information.

and matched the averages by neighborhood. Including this variable along with 2010 average income and our price index yields the model in column (6). The negative partial effect of income, consistent role for the price index, and persistence in environmental attitudes are all confirmed. This finding is also consistent with what we would expect from social interaction models. It also confirms the outcomes we would expect with sorting. Of course, it is important to recognize that none of the estimates from these models has a structural interpretation.

We have used the spatial design of the PASS survey to examine the partial correlations between outcomes that should align based on the sorting framework. Our results offer strong confirmation. Equilibrium sorting models that have been defined in urban and environmental applications describe how heterogeneous households adjust to differences in non-market services across a spatial landscape. They offer the potential means to link economic models to the spatially defined frameworks that underlie the Long Term Ecological sites organized around urban ecological systems. This research suggests that there is the potential for advancing our ability to evaluate maintained hypotheses associated with the sorting logic through coordinated data collection activities in these networks. The research designs of economists, ecologists, and other social scientists in this system would likely benefit. Our findings confirm that the NEP environmental attitudinal index developed by other social scientists appears to serve a role in accounting for sorting outcomes. This result is consistent with the maintained assumptions for the latent heterogeneous preference parameter in these models.

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Table 1: Components of the New Environmental Paradigm for the 2011 PASS Survey in Phoenix

		Contribution to NEP							
		1	2	3	4	5	n	Loading	$r_{i\,NEP}$
1	We are approaching the limit of the number of people the earth can support.	13.9	21.9	12.6	31.0	20.6	804	0.4643	0.51
2	Humans have the right to modify the natural environment to suit their needs.	9.6	29.5	3.4	32.5	24.9	802	0.3980	0.50
3	b When humans interface with nature it often produces disastrous consequences.	4.1	15.8	4.5	39.3	36.3	804	0.4907	0.51
4	* Human ingenuity will insure that we do NOT make the earth unlivable.	13.4	34.0	12.0	25.7	15.0	801	0.3304	0.44
5	Humans are severely abusing the environment.	5.8	10.6	2.6	40.4	40.6	805	0.6241	0.61
6	The earth has plenty of natural resources if we just learn how to develop them.	34.2	39.6	4.0	13.4	8.6	804	0.3147	0.42
7	*,b Plants and animals have as much right as humans to exist.	5.7	9.5	1.7	27.3	55.8	803	0.5002	0.50
8	* The balance of nature is strong enough to cope with the impacts of modern industrial nations.	7.3	25.2	9.3	30.2	27.9	805	0.5633	0.62
9	b Despite our special abilities and humans are still subject to the laws of nature.	2.2	3.7	3.0	31.8	59.2	802	0.2647	0.32
10	* The so called "ecological crisis" facing humankind has been greatly exaggerated.	14.0	25.5	7.7	26.1	26.6	804	0.6155	0.66
11	*,b The earth is like a spaceship with very limited room and resources.	14.4	22.5	5.6	36.4	21.1	801	0.4859	0.52
12	Humans were meant to rule over the rest of nature.	13.1	20.3	5.5	25.7	35.4	802	0.4368	0.53
13	* The balance of nature is very delicate and easily upset.	4.3	15.3	6.0	37.0	37.4	805	0.5699	0.55
14	Humans will eventually learn enough about how nature works to be able to control it.	9.2	24.2	7.5	28.5	30.6	801	0.1970	0.34
15	If things continue on their present course, we will soon experience a major ecological catastrophe.	9.7	17.0	9.1	36.6	27.6	804	0.6009	0.58

Table 2: Relationship of the New Environmental Paradigm and Household Income*

	Full NEP			Reduced NEP1		Reduced NEP2
	(1)	(2)	(3)	(4)	(5)	(6)
Household Income (Thousands)	0.011	0.029	-0.038	0.013	-0.024	-0.015
	(0.98)	(2.25)	(-2.54)	(0.97)	(-1.20)	(-3.05)
Average Test Scores	——	-0.50	——	-0.043	——	——
	——	(-2.57)	——	(-2.15)	——	——
AQI	——	-0.80	——	-0.203	——	——
	——	(-1.49)	——	(-3.63)	——	——
Price Index	——	——	6.963	——	3.698	1.740
	——	——	(4.08)	——	(1.65)	(3.19)
Parsimonious NEP (2006)	——	——	——	——	——	0.141
	——	——	——	——	——	(1.51)
Intercept	51.51	60.36	54.335	15.009	4.648	14.337
	(55.34)	(16.94)	(52.08)	(4.04)	(3.39)	(8.79)
R^2	.026	.187	.334	.286	.071	.382
n	39	39	39	39	39	34

* The numbers in parentheses are t-ratios for the null hypothesis of no-association.

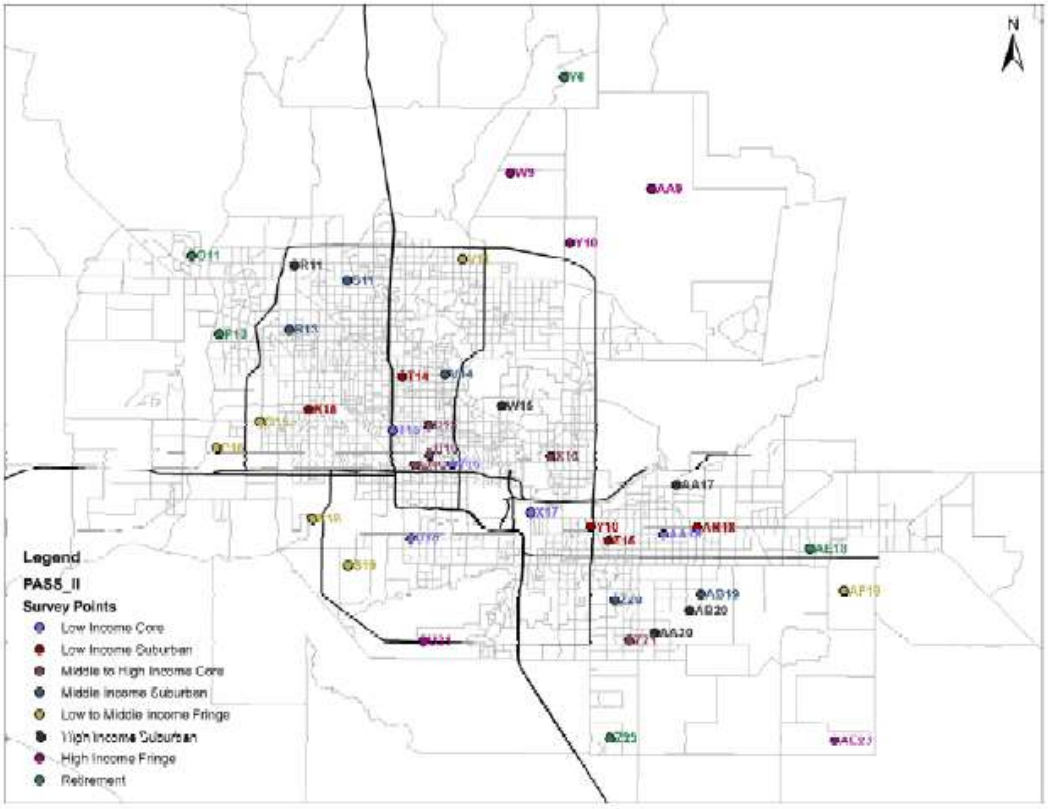

Figure 1: PASS 2011 Neighborhoods