Green pastures: Do US real estate prices respond to population health?

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ABSTRACT

We investigate whether communities with improving population health will subsequently experience rising real estate prices. Home price indices (HPIs) for 371 MSAs from 1990 to 2010 are regressed against life-expectancy five years prior. HPIs come from the Federal Housing Finance Agency. Life expectancy estimates come from the Institute of Health Metrics. Our analysis uses random and fixed effect models with a comprehensive set of controls. Life expectancy predicted increases in the HPI controlling for potential confounders. We found that, this effect varied spatially. Communities that invest their revenue from property taxes in public health infrastructure could benefit from a virtuous cycle of better health leading to higher property values. Communities that do not invest in health could enter vicious cycles and this could widen geospatial health and wealth disparities.

1. Introduction

The link between community prosperity and longevity is well established (Chetty et al., 2016). There are few studies, however, that assess whether improvements in community health raise housing prices by increasing buyers' competition for a chance to live in healthier neighborhoods. We review the dynamics that shape community resources and health by combining the main tenets of the socio-ecological framework with that of the New School of Urban Sociology. Hedonic pricing theory provides us the conceptual umbrella and methodological approach to do so. There are many facets that make a location attractive to home buyers. We test whether the factors that attract people to bid up real estate values might also coincide with factors that make populations healthy.

The socio-ecological framework has been widely used in medical sociology and posits that, in addition to individual socioeconomic factors, the broader contexts in which our lives unfold affect our health and longevity (Stokols and Daniel, 1992). The community physical and social environment are such contexts that shape exposure to risks and access to health furthering resources (Glass and McAtee, 2006; Phelan et al., 2010; Stokols and Daniel, 1992). Studies have shown that for example, neighborhood income, wealth, home ownership and crime all had an effect on a wide range of health outcomes including longevity (Ashe et al., 2003; Kaplan and Geling, 1998; Kawachi et al., 1999; LaVeist and Wallace, 2000; Murray et al., 2006; Pereira et al., 2013).

While social ecology provides a theoretical framework that explains the spatial variation in health with spatial variation in community socioeconomic resources, a part of urban sociological theory focuses on explaining how spatial variation in community resources and features are created by the dynamics that unfold between urban dwellers with different socioeconomic resources (Logan and Molotch, 2007). The Chicago School of urban ecology, the earliest theory of urban sociology, proposes that residents compete for urban space and amenities much like species compete within an ecological system (Park et al., 1984). While the Chicago School sees competition as a way to assure optimal allocation of resources across the urban landscape, the New School of Urban Sociology highlights that competition is regulated mainly by real estate prices and thus leads to the exclusion of non-solvable demand and unequal access to urban amenities and investments into community development over time (Gottdiener and Hutchison, 2011; Logan and Molotch, 2007).

We use hedonic pricing theory as an umbrella to integrate both the medical and urban sociological schools of thoughts. Factors that affect health, such as crime, walkability, healthy food access, alcohol and tobacco outlets and social capital (Kaplan and Geling, 1998; Kawachi et al., 1999; LaVeist and Wallace, 2000; Pereira et al., 2013) can be observed by home buyers and can attract or repel them based on the degree to which buyers perceive their attractiveness. We do not suppose that home buyers commonly consult epidemiological data on health in their home purchasing choices. Rather, we ask whether places with features that further population health attract higher bids for property. Hedonic pricing theory provides an econometric approach for

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assessing residents' competition for community resources (Harrison and Rubinfeld, 1978; Rosen, 1974). Sherwin Rosen advanced hedonic pricing theory and suggested that "goods are valued for their utility-bearing attributes" (Rosen, 1974, p.34) even in the absence of a market for some of these attributes (Hite et al., 2001). Accordingly, home buyers who bid on property are attracted to various amenities of the property and its environment, creating spatial differences in prices of otherwise identical goods (Rosen, 1974). We hypothesize that a residential property and the neighborhood it is located in present an unspecified set of visible markers that buyers find valuable. Since safety and health are universally valued, we hypothesize that home prices reflect health furthering amenities and population health.

We assume that the effect of observable and desirable health promoting features of communities can be proxied by community level life expectancy. We use a hedonic pricing model to gauge the urban ecologic premise that home buyers compete for access to health promoting communities. We hypothesize that increases in community life expectancy lead to subsequent increases in real estate prices. Housing prices influence the tax base of a community and the community's potential for future spending on amenities and health. A health-housing price link would have significant socioeconomic and public health implications by allowing communities to improve property values and tax revenue by public spending on public health and health promoting infrastructure. This could create a virtuous cycle of improvements of community fiscal solvency, public health spending, and better population health. However, this mechanism would tend to exacerbate health and wealth disparities between "have" and "have-not" communities. On a global scale, the last 200 years have shown divergence between countries in GDP and life expectancy based on mutually reinforcing links between population health and wealth (Riley, 2001). This analysis will explore whether a similar phenomenon could be leading to divergence in health and wealth across place on a sub-national scale.

We also hypothesize that there could be spatial variation in the strength of the population health housing price relationship across the country. Buyers in some markets might be imperfectly appreciative of how healthy and safe a location is or, they may have their home purchasing decisions influenced by cultural/ethnic preferences or practical issues such as commuting time. These factors might impede the ability of buyers to bid up the prices of the most health promoting communities and, depending on the spatial distribution of such exogenous factors, weaken the health-housing price relationship locally.

Income levels of the municipal government as well as the average home buyer are important confounders in a relationship between population health and housing prices. People with higher incomes have better health and they are also able to pay higher prices for real estate. Simply including measures of population income would be insufficient to fully control for unobservable aspects of affluence that might not be captured by median income or government expenditure in an area. Therefore, we use fixed and random effects models of panel data for the US between 1990 and 2010. Data availability forces us to assess the health-HPI relationship at the MSA level. We grant that there can be substantial variability in property values in small area geographies like census tracts and counties. However, it would be extremely challenging to measure the health-producing properties of a very small geography or a single residence prior to sale. Therefore, we are forced to use HPIs and small area health measures like life expectancy to measure the average healthiness and housing values of an MSA even though the MSA will encompass disparities in both health and property values. We discuss strength and limitations of our approach in detail in the discussion.

We also control for potential confounding factors such as the racial and ethnic composition of the community, the prevalence of college completion, unemployment, changes in the occupation of the local workforce, and domestic, and international net migration. Racial and

Table 1
Descriptive statistics of dependent and independent variables for 1990 and 2010 (first and last year of main analysis).

	1990		2010	
	Mean/ Percentage	SD	Mean/ Percentage	SD
Housing Price Index (HPI)	86.270	11.724	170.578	23.539
Life Expectancy	75.238	1.443	77.933	1.785
Race/Ethnic Diversity HHI[a]	45.897	9.233	41.453	9.799
Percent in poverty	9.898	5.501	9.9714	4.848
Log Income	10.964	0.161	11.041	0.160
Percent Unemployed	6.444	2.000	9.445	2.858
Percent with at least Bachelors	18.530	6.196	24.595	7.501
Percent African-American	9.444	10.206	10.297	10.698
Percent Other Races	2.716	5.056	7.162	6.139
Percent Hispanic	6.375	12.461	11.975	15.267
Population (10k)	37.258	51.082	48.619	71.632
Percent population living in urban areas	68.546	16.239	78.665	13.453
Percent living in own homes	66.304	5.974	66.705	5.575
Occupation (percent of workforce)				
Service Occupations	14.133	2.092	13.105	1.672
Manual Occupations	15.913	4.462	13.696	2.921
Agriculture Occupations	3.031	2.347	2.553	1.412
Other Occupations	66.923	4.794	70.645	3.276
Net Migration (10k)				
International Net Migration	0.118	0.386	0.600	1.594
Domestic Net Migration	0.643	3.754	0.240	1.977

[a] HHI stands for Herfindahl-Hirschman Index of diversity of MSA population of whites, non-Hispanic African American, and Hispanics.

ethnic discrimination has been a feature of US real estate markets and is also correlated with population health. College completion similarly affects real estate buyers' preferences as well as affecting health and health behaviors. Unemployment and the occupational composition of the work force can affect both the demand for housing and life expectancy.

We focus on the urban real estate market using publicly available data on housing prices at the level of Metropolitan Statistical Areas (MSA) from the Federal Housing Finance Agency (2016). This choice deliberately leaves out data from rural areas where transactions are less frequent, and measures of both area-specific real estate prices and life expectancy are less precise.

2. Data

Real estate price indices for this study come from the Federal Housing Finance Agency (FHFA) which provides quarterly housing price indices (HPI) based on all housing transactions for all Metropolitan Statistical Areas (MSAs) from 1975 to 2015. An MSA is an area that consists of an urban core with a population of at least 50,000 and includes adjacent counties that are economically and socially integrated with the urban core (U.S. Census Bureau, 2016; US Census Bureau (n.d.)). MSAs change over time. The FHA recalculates HPIs retrospectively using the latest MSA definitions. Quarterly HPIs that were last updated in 2015 were aggregated into yearly measures.

The FHA HPI is based on all repeat transactions of single and attached single family homes including re-sales and appraisals of properties whose mortgages have been acquired or securitized by

Table 2

Regression Results (coefficients and t-statistics) of fixed effect models 1990–2010 regressing the effect of change in life expectancy on changes in Housing Price Indices (HPI) (Model I) controlling for change in occupational categories (Model II) and immigration (Model III 3, 1991–2010).[a]

	MSA HPI 1990–2010 Model A	MSA HPI 1990–2010 Model B	MSA HPI 1991–2010 Model C
Variables			
Life Expectancy, 5 year lag	8.926***[b]	7.993***	8.408***
	[12.540]	[11.103]	[11.071]
Race/Ethnic Diversity HHI[c]	– 0.013	– 0.199	– 0.077
	[– 0.057]	[– 0.843]	[– 0.297]
Percent in poverty	– 1.857***	– 1.966***	– 1.934***
	[– 5.118]	[– 5.420]	[– 5.013]
Log Income	261.478***	270.757***	291.425***
	[23.783]	[23.234]	[23.373]
Percent with at least Bachelors	1.310***	1.158***	1.417***
	[3.790]	[3.311]	[3.771]
Percent Unemployed	0.947***	1.311***	1.568***
	[4.012]	[5.547]	[6.233]
Percent Hispanic	1.177***	0.869***	0.928***
	[6.426]	[4.646]	[4.600]
Percent African-American	– 3.192***	– 3.476***	– 3.364***
	[– 8.583]	[– 9.386]	[– 8.492]
Percent Other Races	1.298***	1.057***	1.183***
	[5.491]	[4.461]	[4.532]
Population (10k)	0.035	– 0.005	– 0.049
	[1.295]	[– 0.169]	[–1.569]
Percent population living in urban areas	0.153***	0.223***	0.234***
	[3.342]	[4.758]	[4.674]
Percent living in own homes	– 1.014***	– 1.637***	– 1.789***
	[– 4.041]	[– 6.193]	[– 6.345]
Occupations (percent of workforce) 1 year lag, Other occupations omitted			
Service		3.548***	3.707***
		[6.481]	[6.417]
Manual		3.016***	3.151***
		[9.173]	[8.995]
Agriculture		3.302***	3.542***
		[6.257]	[6.325]
Immigration (1 year lag)			
International Net Migration			0.382
			[1.299]
Domestic Net Migration			0.816***
			[12.086]
Constant	– 3384.777***	– 3472.380***	– 3737.400***
	[– 25.195]	[– 24.176]	[– 24.487]
Observations	7665	7665	7337
Number of MSAs	371	371	371
rho[c]	0.959	0.956	0.960
R-squared	0.852	0.855	0.851
AIC	63787.12	63630.77	

[a] Time fixed effects were included in all models but are not shown.

[b] p-values are marked with asterisks as follows: *** p < 0.01, ** p < 0.05, * p < 0.1, calculated with two-tailed tests

[c] HHI stands for Herfindahl-Hirschman Index of diversity of MSA population of whites, non-Hispanic African American, and Hispanics.

Freddie Mac or Fannie Mae (Federal Housing Finance Agency, 2016). The FHA HPI is estimated to include about 90% of all transactions and has been shown to map closely to the US Census Bureau Price Index of New Houses (Silver, 2011). Estimates for U.S. county level life expectancy for 1985–2010 were obtained from the Institute of Health Metrics and Evaluation (IHME) at the University of Washington (Institute for Health Metrics and Evaluation, 2015).

In order to control for potential confounding of the life-expectancy-HPI relationship by other MSA characteristics we use information from the University of Minnesota Integrated Microdata Series (IPUMS) 5-year estimates and interpolate information linearly to obtain yearly estimates (Ruggles et al., 2015). We extract information from IPUMS for the following variables: median income, percent of the population living under the poverty line, the percent population with at least a Bachelor's degree, the percent population unemployed, living in their own homes, living in an urban area, the percent of Hispanics, African Americans and other races/ethnicities and the total population. In addition, we calculated a Herfindahl-Hirschman index (HHI) to measure an MSA's heterogeneity of racial/ethnic groups. Including the HHI together with specific proportions of African American, Hispanic, or other races, enables one to distinguish direct effects of a specific group's prevalence as opposed to the effects of general heterogeneity as reflected by the HHI. The HHI was standardized to vary between 0 and 100.

To assess the potential confounding effect of changes in the labor market we extracted information from the 1980 and 1990 census and the American Community Survey 5-year estimates of 2005–2009 and 2010–2014 on the population occupied by industry. Census coding of occupations changed between 1980 and 2002. Appendix Table A1 shows how we bridged classifications by creating four broad categories of manual, service, agriculture and "other" occupations. Data were then interpolated to yield information by year on the labor market composition. In order to control for the potential effect of changes in migration we used census estimates of yearly net domestic and international migration available for 1990–2010 (US Census Bureau, 2016).

Census occupations, IPUMS and net migration data were obtained at the county level and combined into population weighted MSA averages using the 2015 MSA definition to establish comparability with the HPI data. After combining these historical data sources we are left with 371 MSAs that we can reconstitute historically covering the years 1985–2010. After we assessed the appropriate lag of life expectancy—the procedure is described in detail below —we had a dataset that included HPI, lagged life-expectancy, sociodemographic characteristics and occupations that spanned the years 1990–2010. Adding lagged net migration reduced temporal coverage by 1 year from 1991 to 2010

3. Methods

In order to control for unobserved heterogeneity we estimated random intercepts (Eq. (1)) and random slopes models (Eq. (2)) with HPI as outcome.

$$HPI_{MSA,t} = \beta_0 + \beta_1 LEB_{MSA,t} + \beta_2 X_{MSA,t} + \beta_3 Time_t + \alpha_{MSA} + u_{MSA,t} \quad (1)$$

where $HPI_{MSA, t}$ is the vector of Housing Price Indices of MSAs at time t, $LEB_{MSA,t}$ is a vector of life expectancy at birth of MSAs at time t, X is a vector with characteristics of MSAs, time is a time trend, α_{MSA} is an MSA-specific random intercept for each of the MSAs and $u_{MSA, t}$ is the time varying error term. The random slopes model can be written as

$$HPI_{MSA,t} = \beta_0 + \beta_{MSA} LEB_{MSA,t} + \beta_2 X_{MSA,t} + \beta_3 Time_t + u_{MSA} + \varepsilon_{MSA,t}$$

$$(2)$$

where β_{MSA} is a random slope term that is different for each MSA, u_{MSA} is the between MSA error, $\varepsilon_{MSA, t}$, the within MSA errors and β_0 the intercept and adjusted MSA average of HPI.

To assess whether random effects (RE) or fixed effects (FE) specifications to address MSA level clustering provide a better fit to the data we used the Sargan-Hansen test (Wooldridge, 2002). We also assessed whether time-dummies improved the model compared to using a continuous trend. Lags of life-expectancy of one to five years were evaluated.

We present three types of models. Model (A) includes lagged life-expectancy and socioeconomic and demographic MSA information. Model (B) adds the population in various occupational categories. We used Model (B) to identify the best lag of life-expectancy by testing 1 year to 5 year lags (Table A2). Occupational categories were lagged by 1 year. In order to ensure that the effects of life-expectancy were
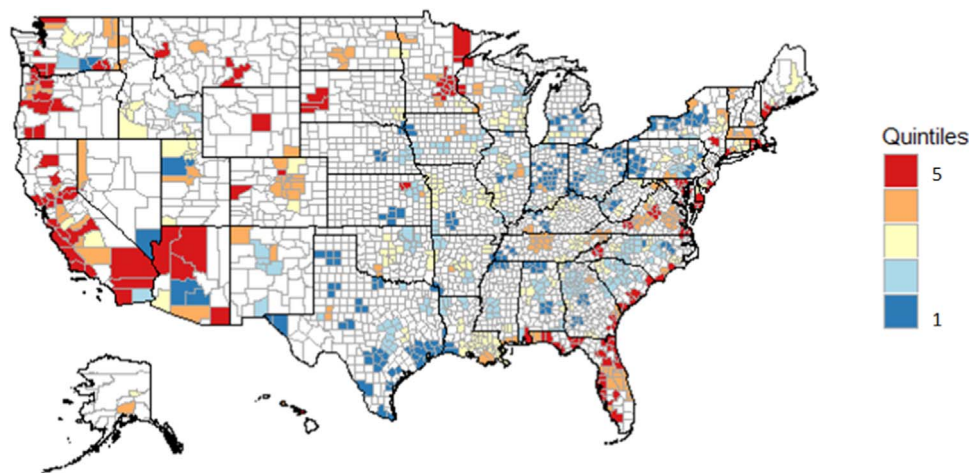
Fig. 1. Geographical variation in the impact of life expectancy on home price index. Warm colors are for MSAs where the estimated random slope between HPI and LEB is higher.

independent of national and county-specific time trends we ran models that interacted continuous time and MSA fixed effects (Table A3).

LOWESS regression was used to assess the functional form of the life-expectancy-HPI relationship and outlier analysis was conducted using Cooks distance. Model (B) was re-run without potential outliers. Removing potential outliers did not change direction and size of coefficients and so outliers are included in the analyses presented here. Finally, we added lagged net-migration estimates to our analysis to control for the potential confounding effect of migration (Model C). Data availability limits this third analysis to the years 1991–2010.

In order to assess and visualize geographic variability in the HPI-life-expectancy relationship we estimated mixed effects models and allowed the beta coefficient for MSA-life expectancy to vary across counties. We then calculate quintiles of the random slope between real estate prices and life expectancy to assess geographical heterogeneity in the relationship of interest.

4. Results

Table 1 presents the summary statistics (means/percentages, standard deviations) for our data for the first and last year of our main analysis (1990 and 2010). MSA averages of HPIs rose steeply across years from 86.27 (SD = 11.73) to 170.58 (SD = 23.54). MSA level life expectancy also increased over the same time (75.24 (SD = 1.44) to 77.93 (SD = 1.79)). Both life expectancy and housing prices exhibit notable geographic variability as indicated by the standard deviations of both variables.

The Sargan-Hansen statistics indicated that the model including fixed effects for MSAs provided a better fit to the data than the random effects models. Testing for time-fixed effects in the fixed effects model showed that the model was significantly improved when year fixed effects were added. All lags, ranging from 1 to 5 years, of life expectancy showed significant positive associations between life expectancy and HPI (Appendix Table A2). A 5-year lag of life expectancy yielded the biggest coefficient and the best model fit as indicated by the AIC.

Table 2 presents results of the MSA fixed effect models, predicting change in HPI with change in life expectancy. Lagged life expectancy was positively associated with HPI in Models A through C. Adding changes in the occupational profile of a community (Model B) increases model fit but changes the effect of life expectancy on HPI only little (from 8.94 to 7.99) leaving the life expectancy HPI relationship significant and strong. Sociodemographic MSA features were associated with HPI in the expected direction. MSAs with increasing percentages of residents with Bachelor's degrees and income exhibited increases in HPI and increasing percentages of the population living in their own homes is associated with decreases in HPIs. Increases in the

percentage of the Hispanic population and other races is, interestingly, associated with HPI increases in all models. Controlling for domestic and international migration for the years 1991–2010 (Model C) affects the life expectancy-HPI relationship only little.

Fig. 1 displays the quintiles of the random slope of lagged life expectancy for each of the MSAs. The map illustrates that the effect of life-expectancy on HPI is strongest along the East Coast and the Florida Coast. Along the West Coast we find a similar pattern at the mid-to-southern California Coast and around Los Angeles as well as in areas in the North of Oregon and Seattle. Generally, MSAs in the South and Mid-West show the smallest effect strength, with the exception of northern Minnesota and the Minneapolis area.

5. Discussion

We used a hedonic pricing model to assess the effects of life expectancy on housing prices in US Metropolitan Statistical Areas. We found that, with every unit increase of lagged life-expectancy, the HPI increased by about 8 points. For reference, a 8 point HPI increase in 2010 amounts to a 5% change in the average housing prices. We also found that the magnitude of life expectancy's association with HPI differed across US regions.

Economists have used hedonic housing price models to assess the effect of various health related environmental characteristics on housing prices such as clean air (Harrison and Rubinfeld, 1978; Smith and Huang, 1995), open and covered landfills and proximity to country clubs (Hite et al., 2001). Gayer et al. analyzed the effect of the release of EPA information on cancer risk surrounding hazardous waste dumps and found that prior to EPA reports buyers were willing to pay a prime to avoid risk. However, once the EPA information was released and uncertainty about cancer risk was reduced, housing prices adjusted accordingly (Gayer et al., 2000, 2002).

In past studies economic analysis has assessed the effects of environmental features on housing prices (Gayer et al., 2002; Harrison and Rubinfeld, 1978). At the same time, the public health literature has established the association of a range of environmental risk factors with numerous health outcomes. Researchers have linked community level socioeconomic deprivation and unemployment to cardio-vascular risk (Diez-Roux et al., 1997; Yang and Diez-Roux, 2013), diabetes risk has been found to be associated with community food and physical activity resources (Auchincloss et al., 2009), presence of highways, traffic volume and air pollution have been shown to be associated with childhood asthma incidence (Juhn et al., 2005; Liu et al., 2014) and food outlets, green spaces, land use patterns and crime have been linked to obesity risk (Lovasi and Schwartz-Soicher, 2013; Schwartz et al., 2011; Walker et al., 2010; Wolch et al., 2011).

Our study situates itself at the crossroad of the hedonic-housing-price and neighborhood-health literature by studying the relationship between housing prices and health. Our findings suggest that there is an association between improvements in life expectancy and subsequent increases in housing prices over the next one to five years. Our findings suggest that community features that are associated with better population health may be driving up housing prices. In the long run these price rises could exclude poorer consumers from access to the healthiest communities. Spatial differences in the relationship of life-expectancy and housing prices suggests that the competition for health promoting features might be more intense along the East Coast, Florida, Washington State and the California Coast. An association of life expectancy with HPI in the Midwest and South that is less strong than on the coasts, might be due to imperfect information or other barriers to choosing healthy communities, such as racial preferences or commuting patterns. Our estimates suggest that these areas offer opportunities for consumers to get a better than average deal on real estate associated with better health. Future research will have to investigate the factors associated with the spatial differences in the HPI-life expectancy relationship.

In addition to the novel perspective of our study on health and housing prices; our analysis has several strengths. To our knowledge no prior study has assessed the role of health in housing prices using a time-series of 20 years. We also make use of an extensive set of covariates to control for potential confounders of the HPI-life expectancy relationship. Using a fixed effects model, furthermore, assures that we control for time varying confounders. Our model uses the arrow of time to ensure that the health changes precede the price changes. As mentioned above, we control for a reasonable set of potential confounders and the effects of lagged life expectancy on HPI were large and robust to a range of model specifications. Furthermore, the fixed effects specification controls for non-time varying confounders like climate and shoreline.

While our modeling approach has the above mentioned strengths. It also has important limitations. Although our models help with unobservable confounding, they are not sufficient to drive causal inference. Dynamic panel effects, also known as Nickell bias (Nickell, 1981) could potentially drive a non-causal association between changes in X and subsequent changes in Y if the rate of change of the residuals is entwined. In addition, we are only provided with HPI information for MSAs. Limiting our analysis to MSAs, however, leaves rural areas excluded. Therefore, our results cannot be generalized to non-metropolitan areas. We are also considering the housing market at a large geographical scale: the MSA. Likely, we are missing important variations of health and housing prices at smaller scales of communities within MSAs (Eberhardt and Pamuk, 2004). Zip-code level information is available but is less reliable because of low numbers of transactions at the zip-code level for each year (Silverstein, 2014). Furthermore, using all-transactions, which include resales and appraisals have been shown to have an appraisal bias and slightly lag market trends. In 2006−2007 the difference between the FHA-HPI and the Standard & Poor/Case-Shiller National Home Price Index attributable to the inclusion of appraisals was 1.54% (Leventis, 2008). Short term housing prices tend to be unreliable, and HPI's are retrospectively updated each year. By using 2010 as last data point we benefit from 5 cycles of backward correction for the most recent year of our analysis.

Our study synthesizes findings from the urban and medical sociological literature within a hedonistic pricing approach. We theorize that home buyers are informed actors who choose real estate based on both price and the observations they make about the effects of place on their health. Our results suggest that, via health promoting community features, health itself may become a commodity in the housing market, driving housing prices and likely widening geospatial health disparities. Thus, our results suggest that the basic tenets of the socio-ecological model and of the New School of urban sociology come full circle: It is not only the case that community prosperity affects health. But also, that improvements in health are associated with subsequent improvements in community prosperity as measured by housing prices.

Housing prices affect the community tax base. Our results imply that policies to use property tax funds at the county level to finance effective community wide-increases in population health would be a justified investment and improve the fiscal and physical well-being of a community. Unless there are intrastate transfers of state government funds or federal aid to the poorest and least healthy communities the association that we observed would tend to widen spatial and economic disparities. Counties with good health would have increased revenue to spend on ever increasing health. The degree to which US communities are suffering divergence in health based on this cycle remains for future research.

Acknowledgements

Appendix

See Table A1−A3.

Table A1
Bridged occupational categories 1980/1990 Census and 2005-09/2010-14 ACS.[a]

Category	Census 1980	Census 1990	ACS 05−09 & ACS 10−14
Manual Occupations	T050_015	T039_015	T050_002 Management, business and financial operations occupations (contributes 0.7%)
	Operators, fabricators and laborers	Operators, fabricators, and laborers	T050_003 Professional and related occupations (contributes 0.6%)
			T050_005-T050_008 Service professions (contributes 1.4%)
			T050_009 Sales and related occupations (contributes 1.4%)
			T050_010 Office and administrative support occupations (contributes 5.7)
			T050_011 Farming, fishing and forestry occupation (contributes 9.6%)
			T050_012 Construction, extraction and maintenance (contributes 20.3%)
			T050_013 Production Occupations: (contributes 61.6%)

(continued on next page)

Table A1 *(continued)*

Category	Census 1980	Census 1990	ACS 05−09 & ACS 10−14
Agricultural Occupations	T050_013 Farming, forestry and fishing occupations	T039_013 Farming, forestry and fishing occupations	T050_014 Transportation and material moving occupations (contributes 89.2%) T050_002 Management, business and financial operations occupations (contributes 5.4%) T050_003 Professional and related occupations (contributes 0.1%) T050_005-T050_008 Service professions (contributes 6.1%) T050_009 Sales and related occupations (contributes 0.1%) T050_010 Office and administrative support occupations (contributes 0.1) T050_011 Farming, fishing and forestry occupation (contributes 82.7%) T050_012 Construction, extraction and maintenance (contributes 0.3%) T050_013 Production occupations (contributes 0.3%) T050_014 Transportation and material moving occupations (contributes 0.6%)
Service Occupations	T050_009 Service occupations	T039_009 Service occupations	T050_002 Management, business and financial operations occupations (contributes 0.9%) T050_003 Professional and related occupations (contributes 2.5%) T050_005-T050_008 Service professions (contributes 80.8%) T050_009 Sales and related occupations (contributes 1%) T050_010 Office and administrative support occupations (contributes 1%) T050_011 Farming, fishing and forestry occupation (contributes 0.9%) T050_012 Construction, extraction and maintenance (contributes 0.7%) T050_013 Production occupations (contributes 1.4%) T050_014 Transportation and Material Moving (contributes 1.5%)
Other Occupation	T050_002 Managerial and professional specialty occupation T050_005 Technical, sales and administrative support T050_014 Precision production craft and repair occupations	T039_002 Managerial and professional specialty occupations T039_005 Technical, sales and administrative support occupations T039_014 Precision production, craft, and repair occupations	Remainder

[a] Occupational data was drawn from the ACS via social explorer. Post-1990 categories were created to proxy the 1980 and 1990 occupational categories. The definition of professional categories changed markedly across classifications and weights derived by the Bureau of Labor Statistics (BLS) (www.bls.gov/cps/majocc20021990.pdf) are used to establish a coding scheme that resembles the 1990 and 1980 coding scheme. The BLS created these weights by cross-classifying data from the Current Population Survey that was both coded to the 1990 and 2002 occupation classification. The BLS tables included a 2002 occupational category "Installation, maintenance and repair occupations" that was not included in the occupational data tables. This category contributes no more than 1.5% of employees to any of our cross-classified categories according to the BLS data tables. According to the BLS table that distributes employment from the 1990 to the 2002 occupational classification, our reclassification is true to the 1990 classification by 98.4% to 99.8% for our three main categories. (https://www.bls.gov/cps/majocc19902002.pdf).

Table A2
Fixed effect models comparing 1−5 year lags of life expectancy (Model A− Model E).

	Model A	Model B	Model C	Model D	Model E
VARIABLES					
Life Expectancy Lag 1 year	4.903*** [8.085]				
Life Expectancy Lag 2 year		4.898*** [7.759]			
Life Expectancy Lag 3 year			5.483*** [8.340]		
Life Expectancy Lag 4 year				6.594*** [9.618]	
Life Expectancy Lag 5 year					7.993*** [11.103]
Race/Ethnic Diversity HHI[1]	0.015 [0.081]	− 0.052 [− 0.262]	− 0.097 [− 0.474]	− 0.180 [− 0.825]	− 0.199 [− 0.843]

(continued on next page)

Table A2 *(continued)*

	Model A	Model B	Model C	Model D	Model E
Percent in poverty	− 1.702***	− 1.843***	− 1.960***	− 2.014***	− 1.966***
	[− 5.438]	[− 5.735]	[− 5.904]	[− 5.840]	[− 5.420]
Log Income	235.478***	241.385***	250.158***	258.718***	270.757***
	[23.744]	[23.649]	[23.660]	[23.466]	[23.234]
Percent with at least Bachelors	0.849***	0.867***	0.943***	1.050***	1.158***
	[2.979]	[2.923]	[3.035]	[3.205]	[3.311]
Percent Unemployed	1.470***	1.548***	1.535***	1.411***	1.311***
	[7.848]	[7.804]	[7.258]	[6.335]	[5.547]
Percent Hispanic	0.484***	0.512***	0.597***	0.738***	0.869***
	[3.158]	[3.223]	[3.606]	[4.223]	[4.646]
Percent African-American	− 3.009***	− 3.241***	− 3.366***	− 3.433***	− 3.476***
	[− 9.973]	[− 10.336]	[− 10.227]	[− 9.876]	[− 9.386]
Percent Other Races	1.338***	1.262***	1.193***	1.088***	1.057***
	[6.938]	[6.371]	[5.812]	[4.980]	[4.461]
Population (10k)	− 0.028	− 0.014	− 0.008	− 0.007	− 0.005
	[− 1.298]	[− 0.623]	[− 0.331]	[− 0.258]	[− 0.169]
Percent population living in urban areas	0.259***	0.245***	0.235***	0.226***	0.223***
	[6.445]	[5.955]	[5.517]	[5.099]	[4.758]
Percent living in own homes	− 1.432***	− 1.458***	− 1.492***	− 1.521***	− 1.637***
	[− 6.443]	[− 6.336]	[− 6.232]	[− 6.078]	[− 6.193]
Occupations *(percent of workforce),1 year lag, Other Occupations omitted*					
Service	3.031***	3.320***	3.461***	3.519***	3.548***
	[6.587]	[6.948]	[6.952]	[6.766]	[6.481]
Manual	3.189***	3.351***	3.318***	3.169***	3.016***
	[12.359]	[12.316]	[11.475]	[10.295]	[9.173]
Agriculture	3.120***	3.032***	3.047***	3.150***	3.302***
	[7.254]	[6.773]	[6.484]	[6.346]	[6.257]
Constant	− 2890.072***	− 2952.164***	− 3086.075***	− 3250.519***	− 3472.380***
	[− 23.639]	[− 23.355]	[− 23.534]	[− 23.818]	[− 24.176]
Observations	8857	8590	8293	7985	7665
R-squared	0.871	0.868	0.865	0.860	0.855
Number of MSA	371	371	371	371	371
rho	0.939	0.942	0.947	0.951	0.956
AIC	73,358.59	71,152.31	68,709.47	66,202.22	63,630.77

Note: p-values are marked with asterisks as follows:

**p < 0.05, * p < 0.1, calculated with two-tailed tests.

*** p < 0.01, calculated with two-tailed tests.

Table A3
Model demonstrating that positive effect of life expectancy remains after controlling for potential county trends across time. Model A has time and MSA fixed effects, Model B introduces time as continuous variable, Model C interacts continuous time and MSAs.

Variable	Model A Coef (SE) p-value	Model B Coef (SE) p-value	Model C Coef (SE) p-value
Life Expectancy 5 year lag	7.993	9.435	13.661
	(0.720)	(0.880)	(1.456)
	0.000***	0.000***	0.000***
Race/Ethnic Diversity HHI[1]	− 0.199	− 1.061	− 0.703
	(0.236)	(0.289)	(1.102)
	0.399	0.000***	0.524
Percent in poverty	− 1.966	− 5.039	− 11.104
	(0.363)	(0.433)	(0.719)
	0.000***	0.000***	0.000***
Log Income	270.757	60.099	−194.307
	(11.653)	(12.416)	(17.728)
	0.000***	0.000***	0.000***
Percent with at least Bachelors	1.158	2.285	3.484
	(0.350)	(0.424)	(0.965)
	0.001**	0.000***	0.000***
Percent unemployed	1.311	2.846	0.292
	(0.236)	(0.236)	(0.348)
	0.000***	0.000***	0.401
Percent Hispanic	0.869	0.863	12.566

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Table A3 (continued)

Variable	Model A Coef (SE) p-value	Model B Coef (SE) p-value	Model C Coef (SE) p-value
	(0.187)	(0.230)	(1.139)
	0.000***	0.000***	0.000***
Percent African-American	− 3.476	− 4.980	− 0.132
	(0.370)	(0.452)	(1.563)
	0.000***	0.000***	0.933
Percent Other Races	1.057	− 0.261	− 2.853
	(0.237)	(0.279)	(0.700)
	0.000***	0.350	0.000***
Population (10k)	− 0.005	− 0.018	1.386
	(0.027)	(0.033)	(0.371)
	0.866	0.580	0.000***
% population living in urban areas	0.223	0.182	− 2.991
	(0.047)	(0.058)	(0.728)
	0.000***	0.002**	0.000***
Percent living in own homes	− 1.637	− 3.099	0.240
	(0.264)	(0.310)	(0.613)
	0.000***	0.000***	0.695
Percent Occupation in Service	3.548	1.428	9.177
	(0.547)	(0.669)	(6.982)
	0.000***	0.033*	0.189
Percent Manual Occupations	3.016	5.262	31.378
	(0.329)	(0.389)	(4.731)
	0.000***	0.000***	0.000***
Percent Occupations in Agriculture	3.302	1.994	25.118
	(0.528)	(0.646)	(13.033)
	0.000***	0.002**	0.054*
	3.302	1.994	25.118
Observations	*7665*	*7665*	*7665*
Number of MSAs	*371*	*371*	*371*

Note: p-values are marked with asterisks as follows:

*** $p < 0.01$, calculated with two-tailed tests.

** $p < 0.05$, calculated with two-tailed tests.

* $p < 0.1$, calculated with two-tailed tests.

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