THE PRICE OF PAVED SURFACES

HEDONIC PROPERTY ANALYSIS FOR THE CITY OF CAMBRIDGE

INTRODUCTION

Although similar in many respects, the 13 neighborhoods in the City of Cambridge vary in terms of income, demographic characteristics, and the built environment. Impervious surfaces are mainly artificial structures—such as pavements (roads, sidewalks, driveways and parking lots) that are covered by impenetrable materials such as asphalt, concrete, brick, and stone. In addition to often being aesthetically unpleasant, these surfaces inhibit the natural infiltration of rainwater into the ground, which results in more runoff and higher peak flows. As climate change increases the amount of high-intensity rainfall events, homeowners in Cambridge neighborhoods with higher density of impervious surfaces may be more susceptible to damage and groundwater contamination.

This investigation attempts determine whether there is an opportunity to prioritize the development of green infrastructure, an alternative to a conventional sewer, in particular Cambridge neighborhoods with higher proportions of paved surfaces, in order to improve housing values and economic characteristics of the area as well as reduce public and environmental health risks of stormwater overflows.

HEDONIC PROPERTY EVALUATION

Residential houses can be thought of as a bundle of attributes, from the lot size or number of bedrooms to quality of the school district. Hedonic models of house prices are a type of econometric model used statistically unbundle these attributes, often to determine willingness to pay for changes in a particular attribute that may be otherwise difficult to observe.

This assessment employs a hedonic property evaluation to assess whether there is a correlation between residential sales prices and environmental characteristics, such as the density of impervious surface of a parcel's encompassing block group.

Neighborhood	Impervious Surface (%)
Strawberry Hill	27.14%
Area 2 / MIT	38.75%
Cambridge Highlands	41.30%
West Cambridge	45.00%
Neighborhood Nine	56.35%
North Cambridge	56.51%
Agassiz	63.30%
Riverside	65.94%
East Cambridge	66.24%
Cambridgeport	68.14%
Mid-Cambridge	73.49%
Wellington-Harrington	79.75%
Area 4	81.35%

Table 1. *Percentage of impervious surfaces in each of the 13 neighborhoods of the City of Cambridge.*

REGRESSION MODEL

$$Log(SalePrice) = \rho Wy + \beta_0 + \beta_1(ImpSurf) + \beta_2(LivingArea) + \beta_3(Bedrooms) + \beta_4(Baths) + \beta_5(Total\_land) + \beta_6(DistOS) + \beta_7(DistMBTA) + \beta_8(DistFSR) + + \beta_9(pctNonwhite) + \beta_{10}(MedIncome) + \beta_{11}(TreeCount) + \mu$$

METHODOLOGY

Data Cleaning & Preparation

Analysis began by joining tabular Residential Sales Data from the City of Cambridge Property Database with the city's GIS Parcel Data Layer by their Map and Lot Number to get geo-spatial housing price data. The dataset includes sale price, date and several other important explanatory variables related to housing characteristics. Extreme outliers were excluded from the data, and Sales Price was log-transformed to account for its heavy right-skew.

Locational characteristics were calculated for each parcel using the Near tool, and joined to the housing sales attribute table. To get a sense of the neighborhood two block-group level characteristics were also selected: the median household income (in 2014 USD), and proportion of the population that is non-white, both from the U.S. Census Bureau's American Community Survey (ACS) 5-year estimates for 2010-2014.

Exploratory Analysis

Exploratory Spatial Data Analysis was undertaken to get a sense of the variables, how they relate to each other, and what is an appropriate weight matrix to use for the spatial regression. Impervious Surfaces appear to be strongly auto-correlated (clustered), and showed strikingly different rates between the 13 neighborhoods in the City of Cambridge.

Spatial Regression

A spatially-lagged regression model was run in GeoDa for the outcome variable, Log(SalesPrice) on the 11 explanatory variables, using a 1st order Queen's case weight matrix. The regression showed a poor fit with an R^2 of 0.23. Results are listed in the table above.

Table 2. Results—Spatial Hedonic Regression of Log(SalePrice)

Category	Variable Name	Coefficient	Standard Error
Spatial Lag	*W_LogPrice*	0.4977*	0.0417
	Constant	6.448753*	0.5459
Housing Characteristics	*living_area*	0.000124*	2.93E-05
	bedrooms	-0.0266	0.0177
	bathrooms	0.2424*	0.0237
	total_land	1.7310	0.1562
Location Characteristics	*dist_OS*	4.52E-06	6.23E-05
	dist_mbta	-2.56E-05	1.55E-05
	dist_FSR	-5.91E-06	4.86E-06
Neighborhood Characteristics	*pctnonwhite*	-0.3407*	0.1409
	med_income	4.43E-07	5.62E-07
Environmental Characteristics	*tree_count*	8.37E-05	6.61E-05
	imp_surf	-0.0334	0.1355

* indicates significance at 0.05 level. Weight matrix: 1st Queen's case

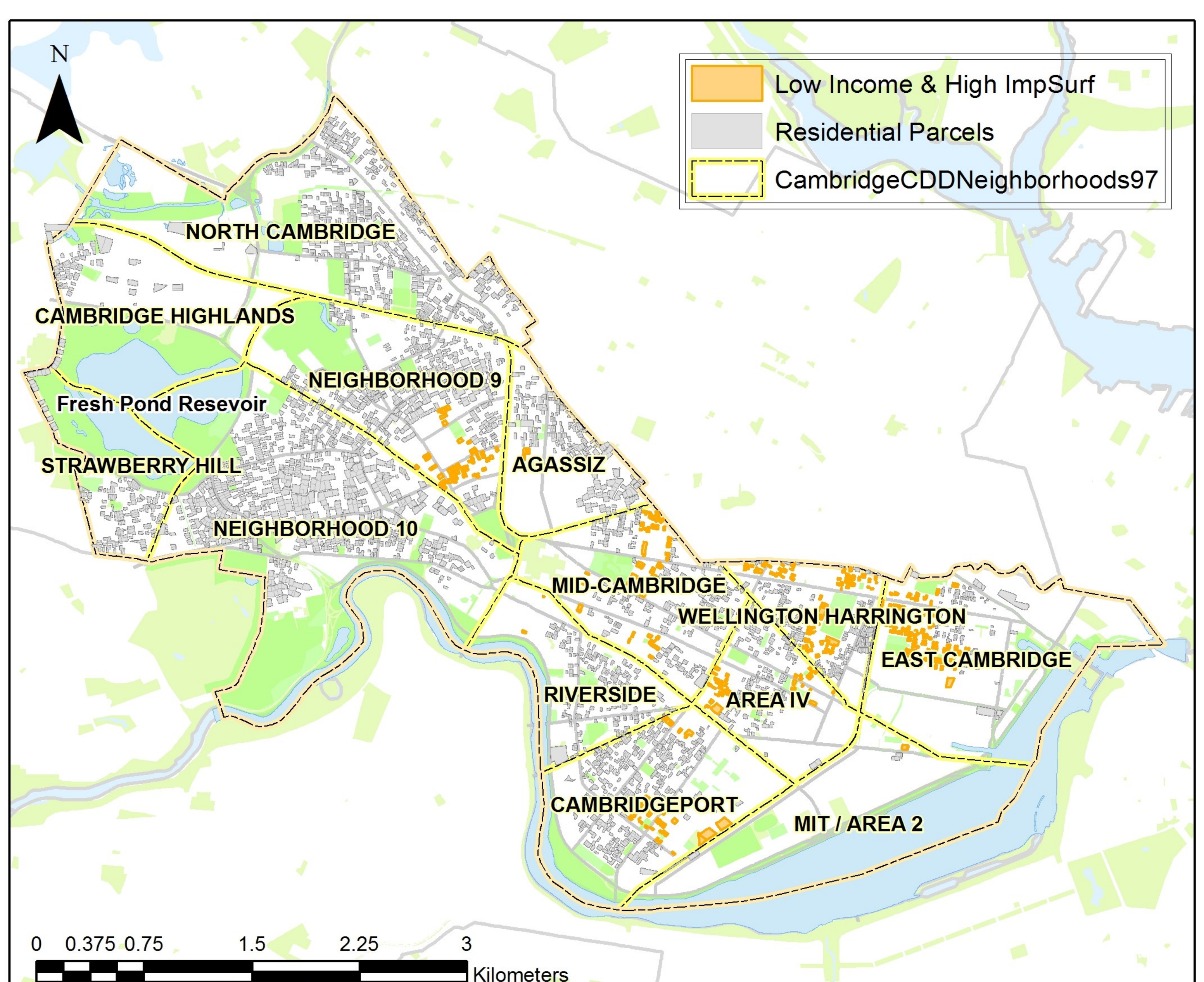
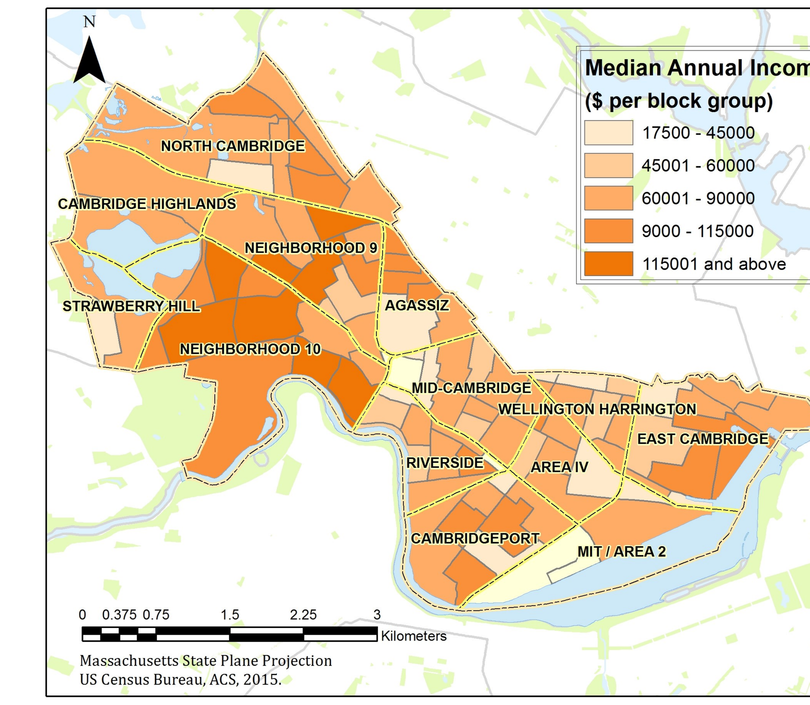


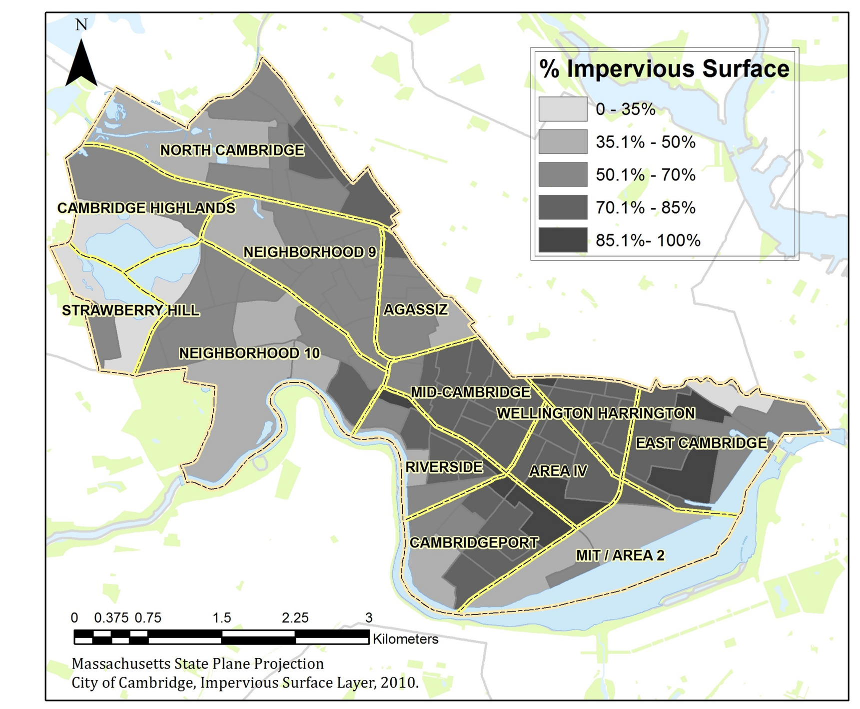
Figure 1. *Parcels in block groups with low median household income (under $55,000 per year) and high rates of impervious surface density (above 60%), from GeoDa Local Bivariate Moran's I on ImpSurf and med_income.*

RESULTS & DISCUSSION

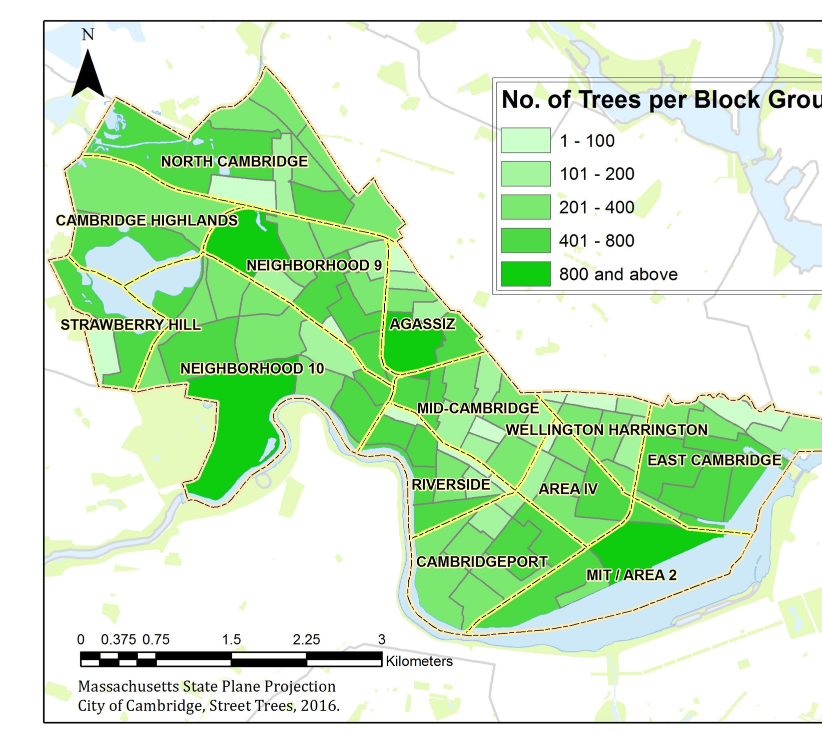
Results indicate that spatial proximity to other high value home is an important predictor of sales prices, and that while the sign on the coefficient for *ImpSurf* was negative as expected, the coefficient itself was not significant. Despite this challenge, the analysis does seem to indicate an inverse relationship between impervious surface density of a block group and median household income. This finding may shed light on why the regression outcome did not match expectations-- the overlap between income differences and impervious surface density may be such that once income is controlled for, impervious surfaces have no effect on home sales prices. An auxiliary regression was run on *ImpSurf,* and indeed showed a significant impact of income level on impervious surface density.

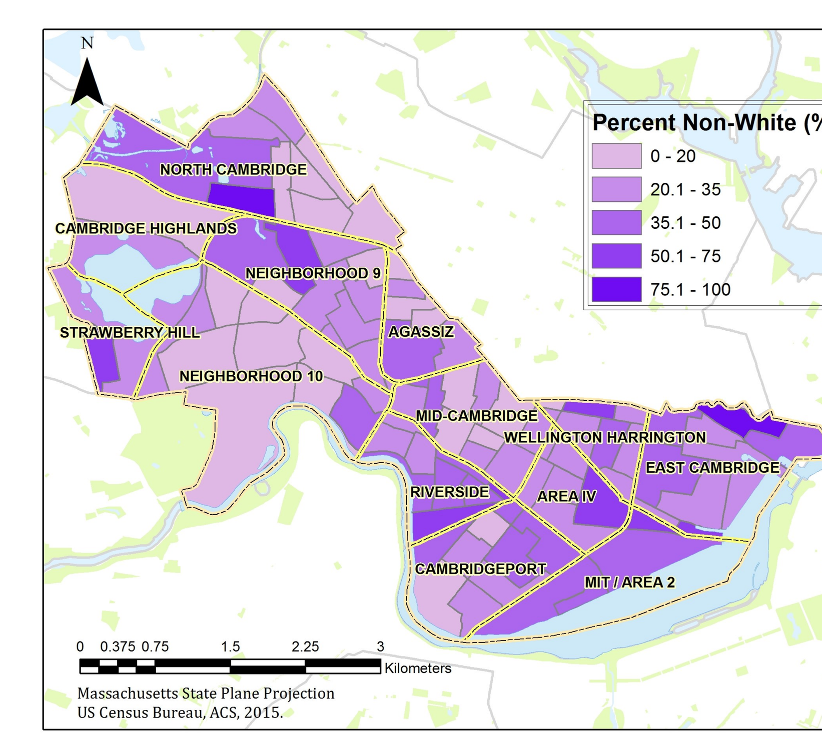
The main strength of the hedonic property evaluation is that it allows analysis of attributes based on revealed, rather than stated, preference. However, as shown here, this method may be limited by data availability, buyers abilities to pay for all the desired attributes, and spurious relationships between environmental and economic variables of interest.





ImpSurf: Global Univariate Moran's I = 0.740198





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SOURCES:

City of Cambridge Residential Sales Data FY 2015, Cambridge Property Database, 2015.

Impervious Surface, Cambridge Open GIS Data, 2010.

U.S. Census Bureau, 2010-2014 American Community Survey 5-Year Estimates, TIGER Line, 2014.

Open Space, Cambridge Open GIS Data, 2015.

MBTA Rapid Transit, MassGIS Data, 2014.

Water Bodies, Cambridge Open GIS Data, 2010

Street Trees, Cambridge Open GIS Data, 2016.