The Rise and Effects of Homeowners Associations

Online Appendix

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Appendix A

Clustering Algorithm Used to Attribute HOA Status to Neighborhoods

DBSCAN ("density-based spatial clustering of applications with noise") is an unsupervised clustering algorithm used to find groups of homes that likely share a common HOA status. The benefit of DBSCAN, relative to grouping by subdivision, is that it can be applied to houses where subdivisions are not recorded. The disadvantages of DBSCAN relative to grouping by subdivision is that the process is somewhat arbitrarily chosen, it is difficult to explain, and DBSCAN does not include homes in an HOA if, for some reason, they were built at a different time than the other homes. Altogether, it is worth grouping by both subdivision and DBSCAN cluster to (1) include more homes in the neighborhood-level measure of HOA status and (2) use the methods to validate one another.

Methodology

DBSCAN works by grouping houses that are within x distance of at least n other houses into core clusters. Any additional houses that are within x distance of at least one house in the core cluster are added to the periphery of the cluster. Remaining houses are not placed in a cluster. The distance used is simple Euclidean distance plus a penalty for dierence in year built. For this paper, clusters are formed with at least $n = 5$ houses in their core, located within $x = 75$ meters of each other if built in the same year or within $\frac{x}{2} = 37.5$ meters of each other if built one year apart. These parameters were chosen to balance (1) confidence that houses in the same cluster really do share the same HOA status and (2) inclusion of as many HOA-member houses as possible, which helps avoid focusing on a small and potentially unrepresentative group. DBSCAN is implemented using the scikit-learn package in Python, which provides full documentation.

Results

Figure A1 shows the degree to which houses in groups formed using DBSCAN and by subdivision all have, or do not have, HOA mortgage flags. If the groups matched HOA boundaries

perfectly and all house-level indicators of HOA status were correct, the histograms would show spikes at 0 percent and 100 percent with nothing in the middle. Table A1 demonstrates that grouping by subdivision or by DBSCAN results in the same HOA designation for over 99 percent of the 14 million houses covered by both methods.

Figure A1: Histograms of the Percentage of Homes within a Subdivision or Cluster Having a House-Level HOA Indicator

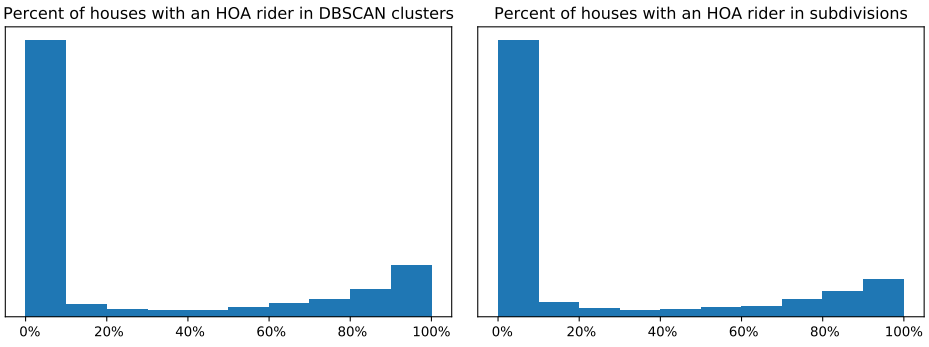

Table A1: Agreement Between Subdivision and DBSCAN Methods for Assigning Neighborhood HOA Status

		Cluster Classification	
		No HOA	HOA
Subdivision	No HOA	8,487,937	40,900
Classification	HOA	17,783	5,513,593

Appendix B

Each line in the table below presents the coefficient and standard error estimates for HOA membership (plus sample size) from OLS and GAM regressions of house price on housing characteristics identical to the ones found in columns (1), (2), and (5) of Table 5 (OLS with block group and month fixed effects, OLS with block group-by-month fixed effects, and the GAM model), but restricted to sales from the corresponding CBSA. The table includes the largest 50 CBSAs in the sample by population.

	(1)	(2)	(3)	(4)
CBSA	OLS	OLS	GAM	Obs.
New York-Newark-Jersey City, NY-NJ-PA	-0.012	-0.020	-0.013	191616
	(0.003)	(0.004)	(0.002)	
Chicago-Naperville-Elgin, IL-IN-WI	0.033	0.027	0.028	254648
	(0.002)	(0.002)	(0.002)	
Dallas-Fort Worth-Arlington, TX	0.068	0.001	0.040	4359
	(0.032)	(0.082)	(0.02)	
Houston-The Woodlands-Sugar Land, TX	0.204	0.055	0.078	3999
	(0.042)	(0.093)	(0.022)	
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	0.049	0.038	0.045	174481
	(0.002)	(0.003)	(0.002)	
Washington-Arlington-Alexandria, DC-VA-MD-WV	0.014	0.006	0.024	167249
	(0.002)	(0.002)	(0.002)	
Miami-Fort Lauderdale-West Palm Beach, FL	0.022	0.019	0.018	266536
	(0.002)	(0.003)	(0.002)	
San Francisco-Oakland-Hayward, CA	0.009	0.009	0.014	157246
	(0.003)	(0.003)	(0.002)	
Phoenix-Mesa-Scottsdale, AZ	0.048	0.041	0.060	637585
	(0.001)	(0.001)	(0.001)	
Riverside-San Bernardino-Ontario, CA	0.024	0.020	0.048	486965
	(0.001)	(0.001)	(0.001)	
Detroit-Warren-Dearborn, MI	-0.032	-0.033	-0.027	31868
	(0.006)	(0.013)	(0.005)	
Seattle-Tacoma-Bellevue, WA	0.058	0.053	0.067	269475
	(0.002)	(0.002)	(0.002)	
Minneapolis-St. Paul-Bloomington, MN-WI	0.058	0.068	0.065	55767
	(0.005)	(0.007)	(0.005)	
San Diego-Carlsbad, CA	0.019	0.022	0.020	190429
	(0.002)	(0.002)	(0.001)	
Tampa-St. Petersburg-Clearwater, FL	0.065	0.062	0.088	287488
	(0.002)	(0.003)	(0.002)	
St. Louis, MO-IL	0.068	0.062	0.070	86708
	(0.003)	(0.004)	(0.003)	
Baltimore-Columbia-Towson, MD	0.075	0.073	0.064	28703
	(0.005)	(0.007)	(0.004)	
Denver-Aurora-Lakewood, CO	0.025	0.019	0.047	289605
	(0.002)	(0.002)	(0.001)	
Charlotte-Concord-Gastonia, NC-SC	0.093	0.095	0.070	223357
	(0.003)	(0.003)	(0.003)	

Pittsburgh, PA	0.034	0.030	0.021	65436
	(0.006)	(0.008)	(0.005)	
Portland-Vancouver-Hillsboro, OR-WA	0.045	0.044	0.062	138205
	(0.002)	(0.003)	(0.002)	
Orlando-Kissimmee-Sanford, FL	0.053	0.046	0.069	224913
	(0.002)	(0.003)	(0.002)	
Sacramento--Roseville--Arden-Arcade, CA	0.011	0.008	0.029	176576
	(0.002)	(0.002)	(0.002)	
Cincinnati, OH-KY-IN	0.080	0.071	0.080	108652
	(0.004)	(0.005)	(0.003)	
Las Vegas-Henderson-Paradise, NV	-0.004	-0.004	0.010	339585
	(0.002)	(0.002)	(0.001)	
Kansas City, MO-KS	0.054	-0.275	0.070	1467
	(0.042)	(0.181)	(0.020)	
Cleveland-Elyria, OH	0.074	0.066	0.068	68868
	(0.005)	(0.007)	(0.004)	
Columbus, OH	0.056	0.040	0.069	88884
	(0.004)	(0.005)	(0.003)	
San Jose-Sunnyvale-Santa Clara, CA	0.026	0.028	0.049	83769
	(0.005)	(0.006)	(0.004)	
Nashville-Davidson--Murfreesboro--Franklin, TN	0.062	0.067	0.060	110001
	(0.004)	(0.005)	(0.004)	
Virginia Beach-Norfolk-Newport News, VA-NC	0.016	0.011	0.033	69989
	(0.004)	(0.004)	(0.004)	
Jacksonville, FL	0.052	0.049	0.064	141650
	(0.003)	(0.004)	(0.003)	
Memphis, TN-MS-AR	0.040	0.036	0.029	82043
	(0.004)	(0.004)	(0.004)	
Oklahoma City, OK	0.146	0.165	0.122	97174
	(0.006)	(0.008)	(0.005)	
Louisville/Jefferson County, KY-IN	0.041	0.034	0.059	54468
	(0.004)	(0.005)	(0.004)	
Richmond, VA	0.012	0.006	0.032	29915
	(0.006)	(0.007)	(0.006)	
New Orleans-Metairie, LA	0.067	0.062	0.056	7988
	(0.01)	(0.014)	(0.009)	
Raleigh, NC	0.084	0.097	0.073	168938
	(0.003)	(0.004)	(0.003)	
Birmingham-Hoover, AL	0.071	0.065	0.077	27167
	(0.009)	(0.012)	(0.008)	
Buffalo-Cheektowaga-Niagara Falls, NY	0.105	0.116	0.087	23746
	(0.012)	(0.018)	(0.010)	
Tucson, AZ	0.067	0.058	0.069	102041
	(0.003)	(0.004)	(0.002)	
Tulsa, OK	0.098	0.106	0.087	47954
	(0.007)	(0.009)	(0.006)	
Fresno, CA	0.069	0.067	0.069	73993
	(0.004)	(0.004)	(0.003)	
Omaha-Council Bluffs, NE-IA	-0.007	-0.034	0.005	32486
	(0.007)	(0.010)	(0.007)	
Bakersfield, CA	0.046	0.060	0.057	86593
	(0.005)	(0.005)	(0.004)	
Greenville-Anderson-Mauldin, SC	0.168	0.158	0.178	24099
	(0.008)	(0.012)	(0.008)	

Knoxville, TN	0.069	0.063	0.074	47351
	(0.006)	(0.006)	(0.006)	
Oxnard-Thousand Oaks-Ventura, CA	0.037	0.033	0.049	54220
	(0.004)	(0.006)	(0.004)	
Allentown-Bethlehem-Easton, PA-NJ	0.023	0.021	0.032	27392
	(0.007)	(0.010)	(0.006)	
Dayton, OH	0.017	-0.022	0.028	11669
	(0.016)	(0.023)	(0.013)	