APPENDIX: FOR ONLINE PUBLICATION

A.1 Further details of the dataset creation

In order to obtain code implementation information going back far enough in time to track adoption dates for ASHRAE-1989, data from a variety of sources were utilized, including an online database maintained by the Building Codes Assistance Project (hereafter BCAP) (BCAP (2010)); archives of BCAP's bi-monthly newsletters going back to 1997, obtained by e-mail from BCAP staff; the Department of Energy's online energy codes database (Department of Energy (2010)); and one report from the Department of Housing and Urban Development (HUD (1997)).[1]

Renovated buildings were dropped from the analysis: although certain types of building renovations are subject to an energy code, and CoStar identifies buildings that have been renovated, it is not possible to identify whether the renovation undertaken in a particular building triggered energy code requirements.[2] Buildings in either treatment category with occupancy rates below 30 percent were also discarded so as to avoid effects caused by vacancy rates due to buildings undergoing renovation or other idiosyncratic (and unobservable) reasons.

Arizona and Colorado are unique states with respect to energy code adoptions. Because these are 'Home-Rule' states, state-level energy standard legislation cannot be legally enforced in individual municipalities and/or counties. However, many jurisdictions in these states have independently adopted energy codes; I have tracked jurisdictional-level adoptions in these states by going through municipal registers (many of which are available online at Municode (2015)), and emailing jurisdictional building officials.[3]

Some states have adopted their own codes, though in several of these cases the state-developed code has adopted one of the ASHRAE standards by reference and made only minor modifications to the original standard. In these states I have relied on estimates of the energy use intensity (in kBTU/s.f./yr.) of each code update and matched them to the ASHRAE or IECC standard version with similar energy saving estimates.

A.2 Estimate of the Extent of Attenuation Bias

Though it is not possible to test for attenuation bias directly, a back-of-the-envelope estimate of the attenuation bias can be obtained from a basic errors-in-variables model (Hausman (2001)), with the following formula:

$$-\frac{\sigma_u^2}{\sigma_x^2 + \sigma_u^2}, \tag{1}$$

where σ_x^2 is the variance of the energy code treatment variable of interest (x), assuming it is measured without error, and σ_u^2 is the variance of random (mean zero) unobserved shocks to x. The observed treatment variable is $\tilde{x} = x + u$. To approximate the variance of shocks to x, I use data from the US Census on the average number of months it takes to construct buildings with 10-19 units from authorization to completion, normalized by 24 months to obtain a variable

[1]ASHRAE 1989 standard adoptions were more difficult to pinpoint, as in some cases different sources cited inconsistent dates. More accurate record-keeping for states' adoptions began improving in the mid-1990s. As a result, I only include ASHRAE 1989 adoptions if all the data sources had matching implementation dates. I was not able to find adoption dates for standards prior to ASHRAE 1989. However, as noted in Section **??**, states only began adopting increasingly stringent energy standards in the mid-1990s as a result of the 1992 Energy Policy Act mandate, and it is this variation I seek to exploit.

[2]For example, the most recently adopted ASHRAE standard is applicable to renovations if more than 50 percent of the lighting fixtures are replaced, but not if the roof and floor are altered where no new cavities are created, if storm windows are installed, or if existing windows are replaced over an area less than 25 percent of the total fenestration area.

[3]One issue that may arise with respect to home rule states is the possibility that treatment status may be correlated with changes in unobserved local regulations, which may bias the estimates. To address any concerns from this possibility, I have also conducted estimation without buildings from home-rule states, with no substantive change in the results.

that ranges between 0 and 1.[4,5] To approximate the variance of the treatment variable, σ_x^2, I use data on the treatment assignment in the rent and sales samples, both of which lead to similar observed variance. An alternative data source was also used to estimate σ_x^2, namely the share of the post-1992, state-level value of commercial construction erected under a code, using the treatment assignment arising from the decision rule used in the main paper. Data on the value of new commercial construction was obtained from the U.S. Census Bureau. Alternating between the rent sample, sales sample, and value-of-construction approaches to calculating the variance suggests the magnitude of the bias ranges from 0.020 to 0.033. This suggests the largest attenuation bias that may be observed is under 3.3 percent. This would increase the value of the rent premium (in levels) from 57 cents per square foot to 59 cents per square foot, and the sale premium from \$26.91 per square foot to \$27.79 per square foot.

A.3 Energy Savings and Capitalization

Engineering studies have been conducted by the DOE to estimate ex-ante average energy savings attributable to ASHRAE standards 1989, 1999 and 2004, and the IECC 2000 (Hadley and Halverson (1993); Federal Register (2002); Federal Register (2008)). These studies estimate the average reduction in site energy use intensity (EUI) per square foot attributable to upgrading to a more stringent ASHRAE code, relative to the preceding code in place, assuming that actual construction practice is conducted in accordance with code requirements. Site EUI is defined as the annual BTU value of energy at the point it enters the building, normalized by building area; its unit of measurement is thousands of BTUs per square foot per year.[6] Based on these studies, the average estimated office building site EUI savings from upgrading to a more stringent standard range from 6-20 percent (Hadley and Halverson (1993); Department of Energy (2002); Department of Energy (2008)). These estimated energy savings are obtained from a weighted average of the simulated EUI savings from buildings located in 11 climate regions in the U.S., with weights corresponding to the share of new building construction in each region.

To obtain an estimate of the average EUI savings arising from the matches in my sample, I calculate a weighted average of the Department of Energy's simulated EUI savings for each treated-control match I observe in the data, in each of the 11 climate regions, with weights corresponding to the share of the in-sample buildings in each region, as listed in Table **??**. Performing this weighted average for the rent and sales samples separately results in similar estimated EUI savings of approximately 12 percent in both samples. Assuming reductions in site EUI lead to proportional reductions in utility costs, and given that office building utilities in the sample cities averaged approximately \$3.80 per square foot per year in 2010 (BOMA (2011)), a 12 percent reduction in annual building energy costs will reduce utility costs by close to \$0.45 per square foot per year. This is the savings figure used in the main text to assess the capitalization of the rent premium in buildings constructed under a code where tenants pay for utilities.

Obtaining an estimate of the impact of a \$0.45 annual utility operating cost saving on selling prices requires an estimate of net operating income (NOI), which I do not observe in the data.[7] Average office building NOI estimates have quite a large range in the literature, from over \$20 per square foot to less than \$10 per square foot (BOMA (2011), Jaffee et al. (2009), Jaffee et al. (2011)). Assuming that the \$0.45 estimated annual utility bill savings per square foot is correct, the observed premium if average NOI is \$10, \$15, or \$20 would be 4.5 percent, 3 percent, and 2.3 percent, and the p-values for a test that the estimated premium is equal to those values are 0.27, 0.13, and 0.09. A study by Jaffee et

[4] I use the 10-19 units measure as it most closely corresponds to the mean building size in my sample. The observed bias range is unchanged if the average time to build is estimated with buildings larger than 20 units instead.

[5] It takes about 14 months, on average, to construct a commercial building. I normalize the variable to lie between 0 and 1 because the treatment variable is a dummy.

[6] The preceding code in place refers to the code version immediately preceding the code under consideration. For example, the code preceding ASHRAE 1999 is ASHRAE 1989, so DOE simulation studies on the savings from upgrading to ASHRAE 1999 are based on a comparison with baseline savings in an ASHRAE 1989 building.

[7] The market price of commercial property can be expressed as $P_0 = \sum_{t=1}^{L} \frac{NOI_t}{(1+i_t)^t}$, where P_0 is the price at the purchase date, L is the expected length of ownership, NOI_t is net operating income (operating income - operating costs) in period t, and i_t is the discount rate at t. Therefore, changes in net operating income affect the selling price. Assuming a flat term structure and that current net operating income is a sufficient statistic for future net income, the market price can be expressed as $P_0 = \frac{NOI}{(i-g)}$, where g is the growth rate of NOI. Therefore, for a given i and g, a 2 percent higher NOI for an energy efficient building is associated with a 2 percent increase in the price. See Jaffee et al. (2011).

al. (2011) in which the authors were able to obtain CoStar data on operating expenses in a subset of buildings finds that the average NOI in their sample is $11.90. If that value is representative of the NOIs in the current CoStar sales sample, the implied premium would be 3.8 percent. The p-value for a test that 3.8 percent is equal to the estimated premium is 0.20.

As has been pointed out by Novan and Smith (2015), in the presence of increasing block pricing (a pricing practice that began being adopted among utilities in the 1980s), the utility bill savings from energy efficiency can be greater than proportional to the energy savings. In residential households, Novan and Smith find that the savings from a new, more energy efficient air conditioner among the heaviest use consumers can be more than four times greater than the savings to the average household. If the savings per square foot are assumed to rise by one third relative to $0.45, to $0.60 per square foot, the p-values for the above tests rise to 0.47, 0.21, 0.13, and 0.33. Overall, given the available data, the estimated sales premium thus plausibly represents full capitalization.

A.4 Additional Falsification Tests

Table A1 presents three additional falsification tests using three different decision rules to create the falsified samples. Columns (1)-(3) present rent sample results and columns (4) and (5) present sales sample results. Panel A uses a falsified sample obtained by subtracting four years from the original treatment assignment; Panel B by subtracting five years; and Panel C by subtracting six years. Each sample maintains a similar year built overlap discrepancy of about two years. As reported in the falsification test in the main paper, each 'Code' variable is statistically insignificant, as is the 'Utilities × Code' interaction. In all three panels, the 'Utilities × Code' point estimate is actually smaller than the 'Code' estimate.[8]

A.5 Pre-Determined Contract Type, and Tenant Sorting

To assess whether the rental contract is predetermined with respect to treatment status, I estimate equation (**??**) but replace Y with a dummy variable for a utilities contract. Effectively, this is a test for whether the treatment and control observations in the matched sample exhibit a statistically significant difference in the fraction of rental contracts that stipulate tenants must pay directly for their utility bill. Columns (1) and (2) of Table A2 presents these results, which are not suggestive of a systematic relation between the type of rental contract and treatment status, given the statistically insignificant difference in the prevalence of utilities contracts between the treated and control buildings.

Testing for whether the rental contract is exogenous to treatment status is one approach to assess the validity of the identifying assumptions. However, this does not control for unobservable differences in the assignment of contract types across treated and control buildings. For example, it is possible that heavy energy using tenants differentially sort into buildings based on treatment status or utility contract type. While I do not observe tenant energy use characteristics, I have been able to access additional information from CoStar on the tenants in California office buildings (representing a subset of the data sample). An analysis on the basis of tenant-level Standard Industrial Classification (SIC) codes between treated and control buildings, and between buildings with and without 'Utilities' contracts, is not suggestive of a systematic difference. Table A3 breaks down California office building SIC codes into 8 different categories, ranging from Agriculture, Chemicals, Oil & Gas, and Transportation, to Financial & Business Services. If certain industries falling within one of these categories tend to be more energy intensive, one might expect differential sorting between more energy efficient (treated) and less energy efficient (control) buildings. For example, it is plausible to expect that more energy intensive tenants may wish to locate in a treated building. In Table A3, both a chi-square goodness of fit test statistic and the normalized difference were calculated for the TREATED, CONTROL, UTILITIES and NO UTILITIES columns. The chi-square test assesses whether the observed share of tenants within each category is statistically different from

[8] Samples obtained from falsified samples created by not only subtracting 4-6 years but also randomly switching state-level decision rules lead to similar results.

the unconditional average in the last row of the table.[9] The chi-square test cannot reject the hypothesis that at the SIC code level tenants sort randomly into treatment. The chi-square test for sorting by utility contract type is rejected, but it is primarily 2 SIC code categories that contribute to rejecting the null: Communications and Publishing & Allied Industries. Together these categories make up approximately 2 percent of the sample. The final columns of Panel A and Panel B of Table A3 also present the normalized difference of the SIC codes within each category. Most of the normalized differences lie below 0.25, with the exception of Publishing & Allied Industries and Retail Trade in Panel A (less than 7 percent of the sample), and Communications and Wholesale Trade in Panel B (less than 5 percent of the sample). Altogether there is limited evidence to suggest tenant sorting on the basis of treatment assignment or contract type.

A.6 Varying the Distance Between Buildings

Table A4 presents results where the maximum allowable distance between buildings steadily decreases in 0.25 mile increments, starting with 1.75 miles and ending with 1.0 miles. The results closely resemble those in the main paper, where the maximum distance is 2 miles. Table A5 presents the same for the sales sample. Again, the results parallel those in the main paper, though some attenuation can be observed as the sample size decreases.

A.7 Manipulating Year of Construction

One concern is that since adoption and implementation dates for energy codes are publicly known, building developers may try to “game” their building’s construction date by rushing to obtain their building permits before the new energy code comes into effect, which would result in a discontinuity in the year built distribution whereby fewer buildings may end up being constructed in the year or two following a code implementation date.

Figure A4 depicts the distribution of building construction dates in the full sample of sales and rent observations, two years before and two years after a code came into effect. Close to 25 percent of buildings were constructed in each of the four years, slightly more buildings were constructed after a new energy code implementations, and there is less than a one percent difference between the share of buildings constructed just before and just after a code came into effect, all of which are not suggestive of strategic energy code avoidance behavior.

[9]The chi-square test statistic is $\chi^2 = \sum \frac{(\text{observed}-\text{expected})^2}{\text{expected}}$, where the observed value is the percent share of observations from a given SIC code in one of the treatment or utility contract categories, and the expected value is the unconditional share in the last row (for example, the unconditional average for tenants in treated buildings is 26 percent).

ADDITIONAL APPENDIX REFERENCES

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Figure A1: Signaling Energy Efficiency

Description

Newer, executive office centrally located on Edgewood Drive. Office features elegant reception area, three offices, plus one executive/conference room office downstairs, break room, large upstairs office, large storage room, and two restrooms.Stunning lake views from upstairs area! Energy efficient features will keep your electric costs low.

Description

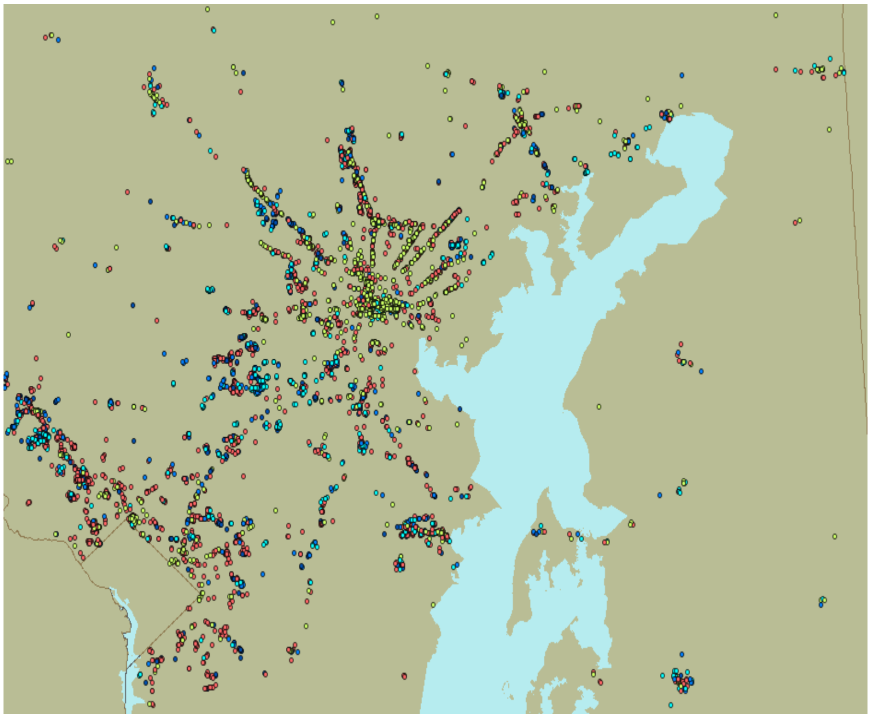
1st Floor - Executive Office Suites
Full Service
Single Office For Lease
High Visibility Location
Ample Parking
New Energy Efficient Building
Interior or Window Offices Available
Includes: Cherry wood flooring, upgraded carpet, 9ft ceilings, alarm system, upgraded kitchen, conference room w/ furniture

Notes: These two advertisements were found by entering search terms "energy efficient" in a multiple listing service for commercial space (www.loopnet.com).

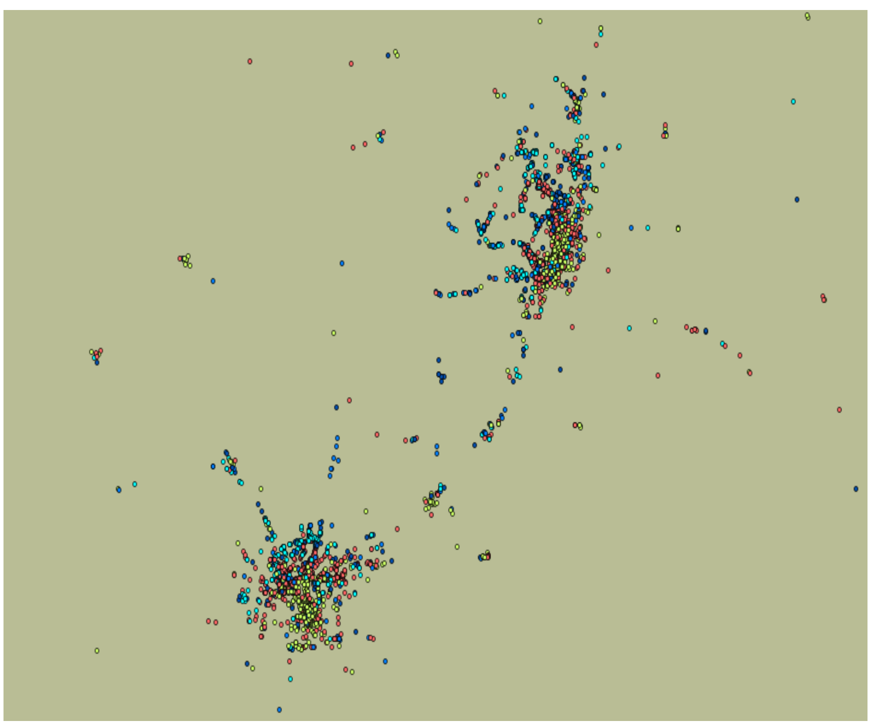
Figure A2: Building Match Example

Notes: Treated and control matches located in Scottsdale, AZ. The building on the left was constructed in 2006. The building on the right was constructed in 2003. ASHRAE 1999 came into effect in September 2003.

Figure A3: Quantiles of the Year Built Distribution



(a) Maryland



(b) Austin and San Antonio, Texas

Notes: Each dot represents a building. The lowest tertiles of the year built distribution (the oldest buildings) are represented by yellow dots, the middle quartiles are represented by red dots, and the upper tertiles (newest buildings) are represented by blue dots.

Figure A4: Buildings constructed pre- and post- code

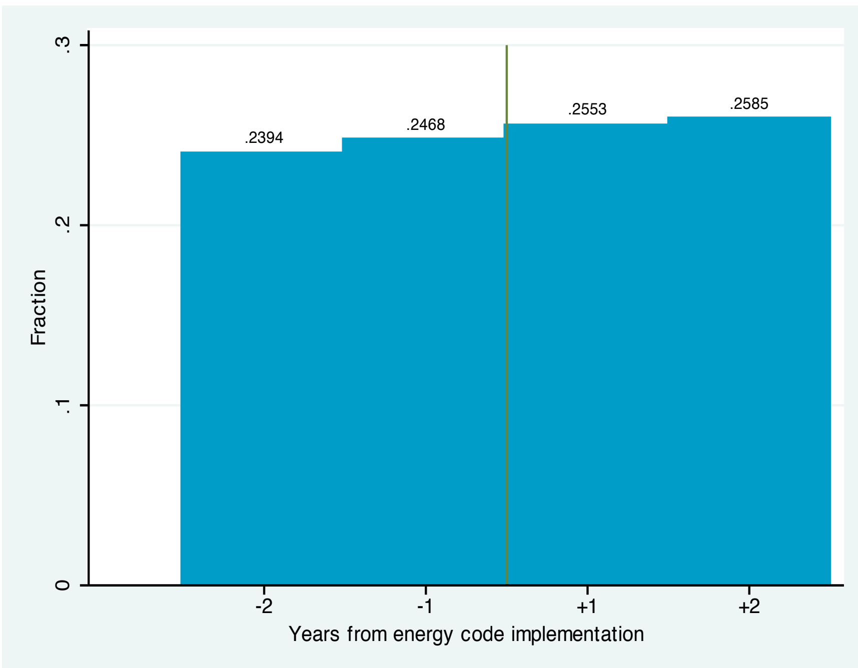


Table A1: Additional falsification tests

	(1)	(2)	(3)	(4)	(5)
		Rent			Sales
			Panel A		
Code	0.0510*	0.0710	0.0730	-0.0689	-0.0035
	(0.0261)	(0.0505)	(0.0764)	(0.0471)	(0.0693)
Utilities x Code			0.0210		
			(0.0707)		
Utilities			-0.171***		
			(0.056)		
Observations	1,405	1,405	1,405	1,279	1,279
R-squared	0.53	0.58	0.59	0.62	0.64
			Panel B		
Code	-0.0037	-0.0151	0.0079	0.0023	-0.0181
	(0.0186)	(0.0223)	(0.0248)	(0.0458)	(0.0549)
Utilities x Code			-0.0294		
			(0.0370)		
Utilities			-0.1771***		
			(0.026)		
Observations	2,113	2,113	2,113	1,277	1,277
R-squared	0.64	0.68	0.69	0.65	0.68
			Panel C		
Code	0.0146	0.0200	0.029	0.0045	-0.0187
	(0.0179)	(0.0203)	(0.0225)	(0.0382)	(0.0405)
Utilities x Code			-0.0210		
			(0.0310)		
Utilities			-0.2108***		
			(0.0296)		
Fixed Effects	YES	YES	YES	YES	YES
Covariates	NO	YES	YES	NO	YES
Clustered s.e.	YES	YES	YES	YES	YES
Observations	2,515	2,515	2,515	1,322	1,322
R-squared	0.64	0.69	0.72	0.68	0.71

Standard errors in parentheses. Clustering is at the market level. *** p<0.01, ** p<0.05, * p<0.1.

Table A2: Robustness to contract pre-determinedness

	(1)	(2)
Dep. Variable:	Utility Contract	
Code	0.034	0.036
	(0.024)	(0.028)
Fixed Effects	YES	YES
Covariates	NO	YES
Clustered s.e.	YES	YES
Observations	2,132	2,132
R-squared	0.56	0.57

Standard errors in parentheses. Clustered errors denotes clustering at the market level.
*** p<0.01, ** p<0.05, * p<0.1

Table A3: Assessing the Evidence for Tenant Sorting

	PANEL A					PANEL B				
	TREATED		CONTROL		*NORM. DIFF*	UTILITIES		NO UTILITIES		*NORM. DIFF*
	N	%	N	%		N	%	N	%	
Ag., Chem., Oil & Gas, Transport	8	27	22	73	0.21	11	35	20	65	-0.18
Communications	6	25	18	75	0.21	6	25	18	75	-1.04*
Financial & Business Services	274	24	871	76	0.10	442	39	703	61	0.05
General Contractors, Construction	26	33	53	67	0.25	45	58	33	42	0.41
Government & Nonprofits	106	28	271	72	-0.18	145	38	232	62	-0.21
Publishing, & Allied Industries	4	29	10	71	-0.53	9	64	5	36	0.15*
Retail Trade	38	35	72	65	0.43	52	47	59	53	0.01
Wholesale Trade	13	22	47	78	0.06	30	51	29	49	0.54
Total	475	26	1364	74	-0.07	740	40	1,099	60	0.01

Notes: The table reports the number (N) and percent share (%) of observations in each industry category. The industry categories represent similar standard industrial classification (SIC) codes. Panel A reports values for tenants located in treated versus control buildings and panel B reports values for tenants who pay for their utility bills directly (denoted 'UTILITIES')versus tenants who do not (denoted 'NO UTILITIES'). The normalized difference, calculated using the mean and standard deviation of SIC codes in each category, is reported in the last column of each panel. Categories that contribute to rejecting the χ^2 test in Panel B are denoted with a *.

Table A4: Rent results varying the distance between buildings

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1.75 mi		1.5 mi		1.25 mi		1.0 mi	
Code	0.018	0.018	0.017	0.017	0.013	0.013	0.005	0.005
	(0.022)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.0237)
Utilities x Code	0.072**	0.072*	0.054*	0.054*	0.065**	0.065*	0.063*	0.063*
	(0.032)	(0.039)	(0.032)	(0.033)	(0.033)	(0.037)	(0.033)	(0.038)
Utilities	-0.1554***	-0.1554***	-0.135***	-0.135***	-0.136***	-0.136***	-0.123***	-0.123***
	(0.026)	(0.029)	(0.025)	(0.026)	(0.027)	(0.031)	(0.029)	(0.032)
Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Covariates	YES	YES	YES	YES	YES	YES	YES	YES
Robust s.e.	YES	NO	YES	NO	YES	NO	YES	NO
Clustered s.e.	NO	YES	NO	YES	NO	YES	NO	YES
Observations	1,861	1,861	1,763	1,763	1,641	1,641	1,469	1,469
R-squared	0.71	0.71	0.72	0.72	0.73	0.73	0.76	0.76

Standard errors in parentheses. Clustered errors denotes clustering at the market level.
*** p<0.01, ** p<0.05, * p<0.1

Table A5: Sales results varying the distance between buildings

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1.75 mi		1.5 mi		1.25 mi		1.0 mi	
Code	0.086**	0.086**	0.079**	0.079**	0.072**	0.072*	0.078**	0.078*
	(0.034)	(0.040)	(0.034)	(0.039)	(0.035)	(0.039)	(0.036)	(0.040)
Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Covariates	YES	YES	YES	YES	YES	YES	YES	YES
Robust s.e.	YES	NO	YES	NO	YES	NO	YES	NO
Clustered s.e.	NO	YES	NO	YES	NO	YES	NO	YES
Observations	1,028	1,028	1,003	1,003	971	971	932	932
R-squared	0.68	0.68	0.69	0.69	0.69	0.69	0.68	0.68

Standard errors in parentheses. Clustered errors denotes clustering at the market level.
*** p<0.01, ** p<0.05, * p<0.1