APPENDIX A. Two Reasons why Clustering Parcels by Owners is Possible

Many owners control a single property, but a significant proportion of owners control multiple properties. Of the 90,655 owners we identified during our study period from 2010 to 2014, about 17 percent of owners consistently possess two or more parcels in each year. Panel A, of the following table, shows the distribution of owners in 2010 over the number of parcels they possess. About 27 percent of parcels are owned by 2.4 percent of owners and 48 percent of parcels are owned by 17 percent of owners. In Panel B, we show Gini coefficients for each year of our study. These show that the concentration of property owners over time is stable.

Table. Concentration of Parcels by Owners

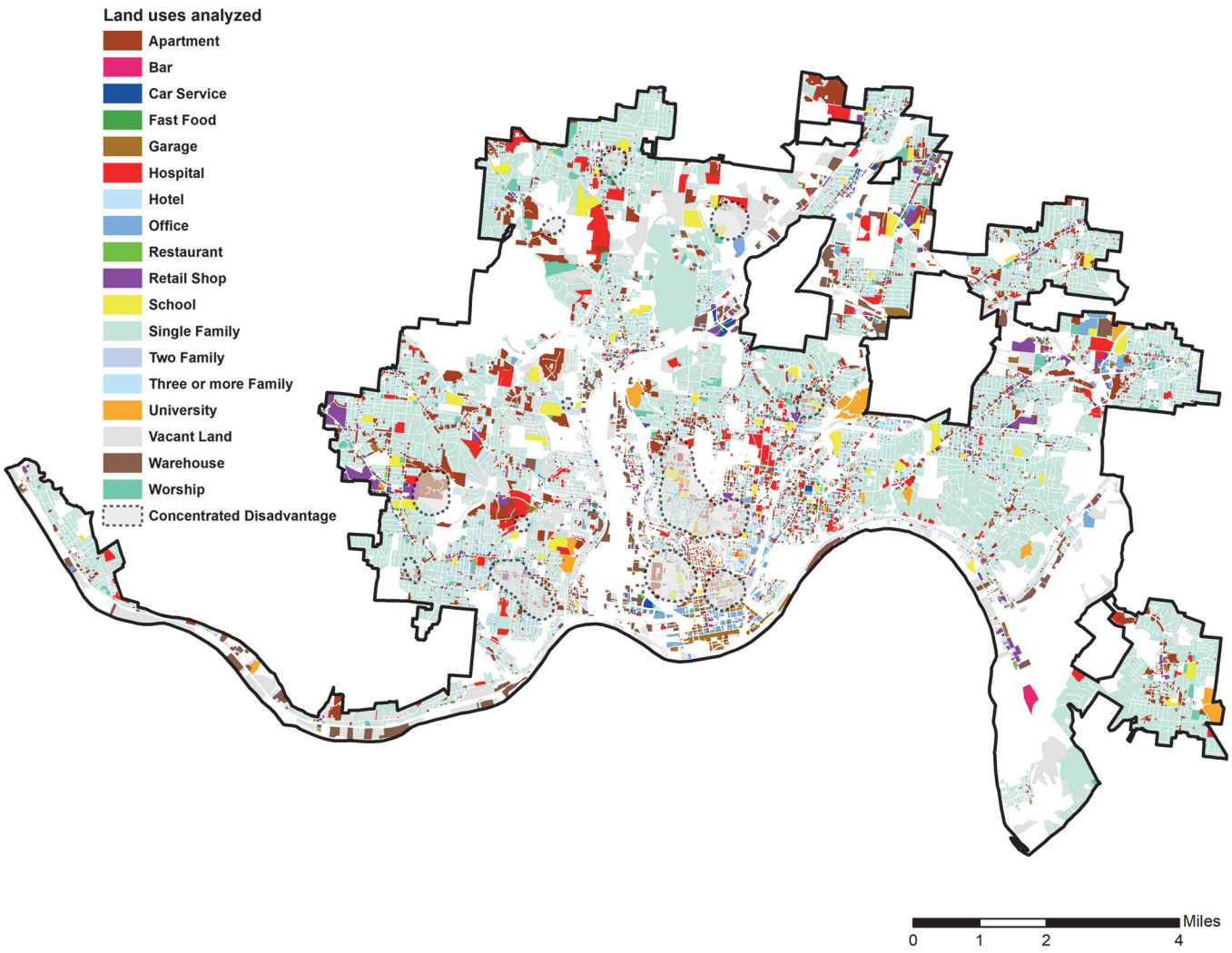
Panel A. Distributions of parcels and owners in 2010

Parcels (N)	Owners			Parcels		
	Number	%	Cumulative %	Number	%	Cumulative %
Over 21	148	0.20	0.20	18,631	16.01	16.01
20	11	0.02	0.22	220	0.19	16.20
19	18	0.02	0.24	342	0.29	16.49
18	24	0.03	0.28	432	0.37	16.86
17	21	0.03	0.31	357	0.31	17.17
16	27	0.04	0.34	432	0.37	17.54
15	30	0.04	0.39	450	0.39	17.93
14	32	0.04	0.43	448	0.38	18.31
13	37	0.05	0.48	481	0.41	18.72
12	48	0.07	0.55	576	0.49	19.22
11	63	0.09	0.63	693	0.60	19.81
10	66	0.09	0.73	660	0.57	20.38
9	90	0.12	0.85	810	0.70	21.08
8	129	0.18	1.03	1,032	0.89	21.96
7	202	0.28	1.31	1,414	1.21	23.18
6	323	0.45	1.75	1,938	1.67	24.84
5	499	0.69	2.44	2,495	2.14	26.99
4	941	1.30	3.74	3,764	3.23	30.22
3	2,112	2.92	6.66	6,336	5.44	35.66
2	7,324	10.12	16.78	14,648	12.58	48.25
1	60,235	83.22	100.00	60,235	51.75	100.00
Total	72,380	100.00		116,394	100.00	

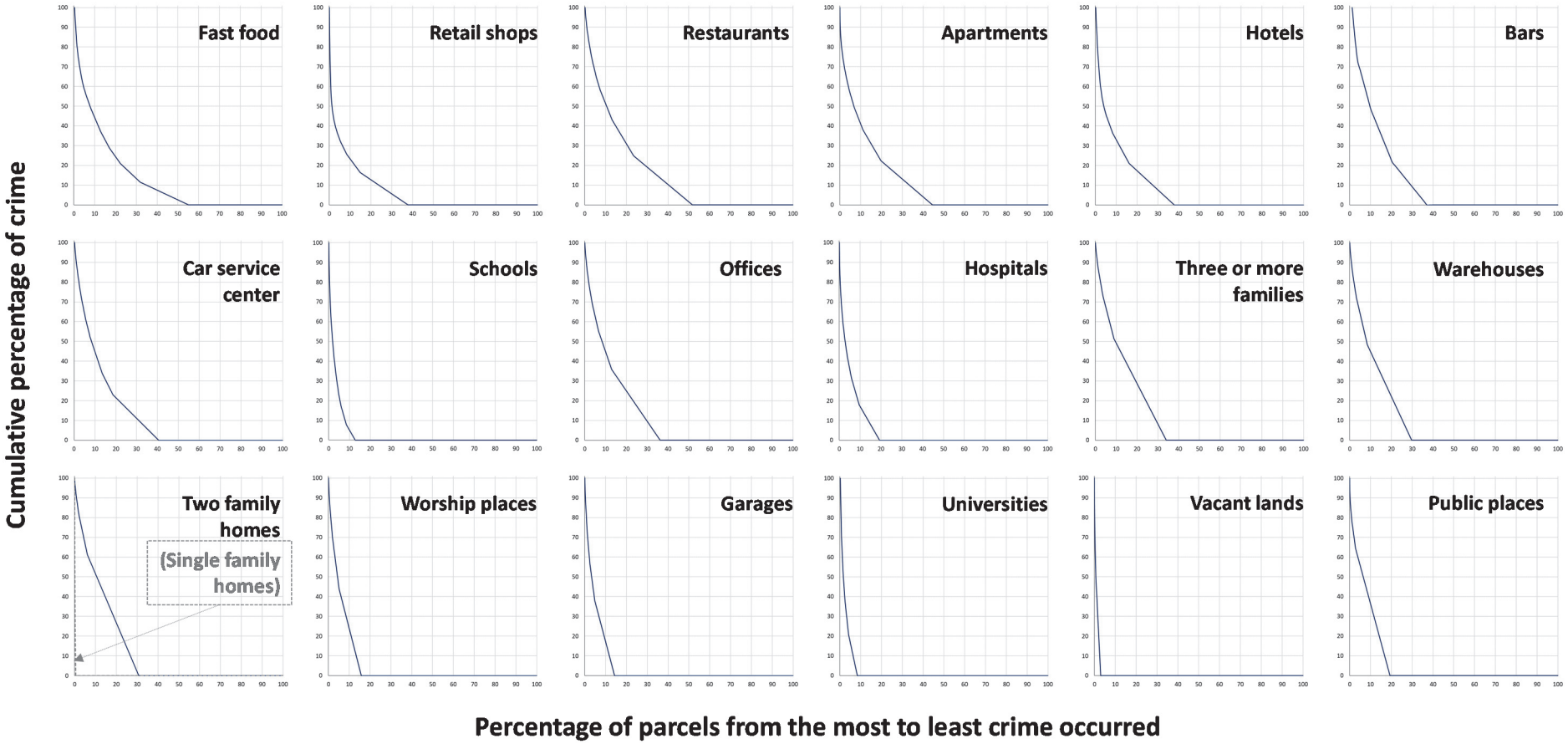
Panel B. Stability of parcel concentration by owner

Year	2010	2011	2012	2013	2014
Gini	0.36	0.36	0.36	0.37	0.37
Owners with 2+ parcels (%)	16.78	16.82	16.89	17.04	17.05
Parcels owned by “owners with 2+ parcels” (%)	48.25	48.45	48.73	49.64	49.64

APPENDIX B. Spatial Distributions of Land Uses across Parcels in Cincinnati

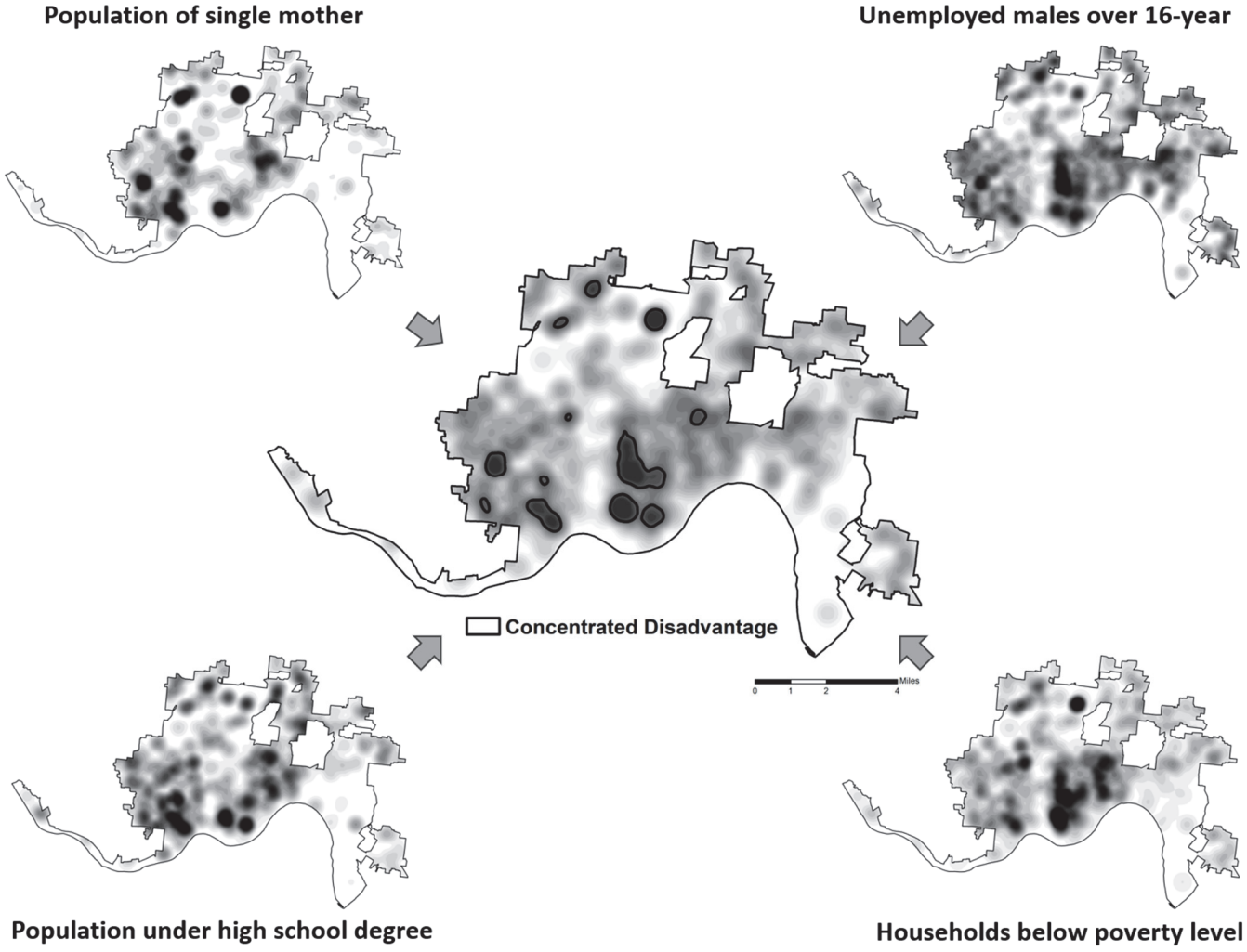


APPENDIX C. Distributions of Crime (in J-curves) across 19 Land Uses



The figure above shows the full distribution of crime for all 19 land uses (including our reference variable). All land uses display an extreme concentration of crime consistent with the findings described in the risky facility literature. It is also useful to know that J-curves of all 19 land uses including car service centers, place of worship, garages follow the well-known Pareto distribution (Newman, 2005; Pareto, 1896). For worship places, this might be one of the first evidence in the U.S. that churches follow the same distribution as bars.

APPENDIX D. Spatial Construct (Index) of Concentrated Disadvantage Area in Cincinnati



Using the kernel density smoothing methods in ArcGIS 10.8, we projected the combined values of four socio-economic factors into an index of concentrated disadvantage by averaging their standardized values onto a map of Cincinnati. This projection created multiple contours corresponding to the values of the index. Then we selected contour polygons from the top 3.7 percent (or z-score higher than 1.96) of the surface. This defined the concentrated disadvantage areas. The figure above illustrates our procedure (see Gorr and Kurland, 2013, p. 412).

APPENDIX E. Omitted Variable Bias

For example, suppose that the true crime and land use (here we use retail shop, for example) equation model is:

$$Crime_i = \beta_0 + \beta_1 Retail_i + \gamma_1 Owner_i + \mu_i \text{ ---------- (1)}$$

Where *i* is property owner's ID
But that since we do not observe owner's place management practice, we estimate

$$Crime_i = \beta_0 + \widetilde{\beta_1} Retail_i + v_i \text{ ---------- (2)}$$

Where $Owner_i$ is omitted in equation (2), thus we could rewrite,

$$v_i = \gamma_1 Owner_i + \mu_i$$

Since $\widetilde{\beta_1}$ is the sole estimate from equation (2)
Then, calling $\widetilde{\beta_1}$ the estimated coefficient of retail shops while omitting owner's place management effect, we can show that

$$E[\widetilde{\beta_1}] = \beta_1 + \gamma_1 \widetilde{\delta_1}$$

$$\text{Where } \delta_1 = \frac{Cov\,(Retail_i, Owner_i)}{Var(Retail_i)} \text{ ---------- (3)}$$

More generally, if $Retail_i$ and $Owner_i$ are correlated and $\gamma_1 \neq 0$, the estimated $\widetilde{\beta_1}$ will be biased. The direction of the bias depends on both the sign of γ_1 and of $\widetilde{\delta_1}$.

In the case of crime equation, if those who own a retail shop are more likely to own/manage another retail shop, then $Cov\,(Retail_i, Owner_i) > 0$.

There are also reasons to believe that, based on Table 1 (top 10 percent owners experience 73 percent of crime on average), retail shop owners are positively related to crime count on average ($\therefore \gamma_1 > 0$).

In equation (3), since $Cov\,(Retail_i, Owner_i) > 0$ and $Var(Retail_i) > 0$, thus δ_1 is in positive direction. Therefore, if we omit the property owner's influence on crime in the land use and crime analysis, the expected value of $\widetilde{\beta_1}$ would be greater than the true unbiased estimate of $Retail_i$ ($=\beta_1$) from equation (1) ($\because \gamma_1 > 0$ and $\delta_1 > 0$).

$$\therefore E[\widetilde{\beta_1}] = \beta_1 + \gamma_1 \widetilde{\delta_1} \neq \beta_1$$

APPENDIX F. Fixed Effects and Random Effects

In the fixed effects transformation, we assumed that the unobserved effect of place management, a_i, and the explanatory land use variables are correlated. This would be true if place managers have consistent practices, business models, they apply across their properties and from year to year. However, it is possible that the unobserved effect a_i can be independent of all explanatory variables in all periods. This would occur if an owner's place management practices are inconsistent over time and over different parcels. If this were true, then using a transformation to eliminate a_i would result in inefficient estimators.

We employed the Hausman test to determine which assumption provides more conservative estimated coefficients for land use variables. The null hypothesis of this test is that the preferred model is random effects. The alternate hypothesis is that the model is fixed effects. The test looks for a correlation between the unique errors and the regressors in the model (Chmelarova, 2007). Our Hausman test results shows that we can reject the null hypothesis at the .001 level. Therefore, we choose the fixed effects model.[1] The test also gives us indirect evidence that place management is a potential confounder of the statistical links between land use and crime.

In addition to this statistical test, we considered another reasons for selecting the fixed effects model over a random effects model. It is safer to assume that place managers are creatures of habit like other people. That is, once they have settled on a business model for operating their property, they will stick with it until there is very strong pressures the change. This does not have to be a universal rule: it merely has to be the dominant pattern of human behavior over several years by most place managers. Further, place management practices will likely be driven in part by the type of property they manage: that is, place management and land are correlated. Different land uses require different management practices, regardless of owner. Bars, for example, will be managed differently than bank branches, apartment buildings, or schools. Thus, there are strong reasons to believe management is correlated with land use. If there is any theoretical or empirical reason to believe that the unobserved effect a_i is correlated with any explanatory variables, we should use fixed effects over random

[1] Hausman statistic $W = (\beta_{RE} - \beta_{FE})'\hat{\Sigma}^{-1}(\beta_{RE} - \beta_{FE}) \sim \chi^2(20) = 473.16$, Prob > χ^2 = 0.0000

effects. Place management theory posits a connection between place management and crime. These reasonable theoretic and practical considerations imply that we must consider the land use – crime link is spurious: created by links between management and crime and management and land use, but perhaps not by a link between land use and crime.

Wooldridge (2009) provides an example for why employing fixed effects over random effects using educational data. If one is interested in the effects of measured teacher quality on student performance, eliminating a class effect also eliminates any observed measures of teacher quality because all students within a cluster have the same teacher. Likewise, without considering the place management effects on multiple land use parcels, the estimated relationships between land uses and crime would be biased, or their standard errors would be incorrect.

APPENDIX G. Proportion Variance Explained

It is clear that the omitted variables connected to ownership impact crime. Not accounting for them usually inflates the relationship between the land use and crime, but for some places, it suppresses the relationship. How much does place management influence crime? We cannot provide a specific answer for each land use, but we can give a general answer.

We calculate the proportion of variance explained by property owners as level-2 units using the Intraclass Correlation Coefficient (ICC). A large value of ICC is only possible when observations from the same cluster are more similar to each other than to observations from different clusters. Large ICC values are additional evidence that the land use observations are not independent: that assuming they are independent provides incorrect estimates of variance, and therefore p-values.

We use the Hierarchical Linear Model (HLM) 7 software package to calculate the ICC. In the unconditional model only with the outcome variable on the left-hand side while both constant and error terms on the right-hand side of the equation[2], the total variation in the outcome variable can be divided between variation over parcels and variation on a property owner. The total variance in outcomes within property owner that can be explained by a level-1 model is σ^2, while τ_{00} is the total explainable variation at level-2 (among property owners). This model serves as baseline for comparison with subsequent, more complex models.

The intraclass correlation coefficient as follows represents the proportion of the variance in outcome among the property owners:

$$ICC\ (\hat{\rho}) = \frac{\hat{\tau}_{00}}{\hat{\tau}_{00} + \hat{\sigma}^2} = \frac{1.06}{1.06 + 1.83} = 0.3667$$

Thus, one third of the variance is due to property owners, and the remaining two thirds of the variance in crime is due to land use, control variables, and their interactions. The fact that the intraclass correlation is not zero

[2] A fully unconditional model can be written as follows, where *i* is a parcel and *j* is a property owner.

$$Crime_{ij} = \beta_{0j} + \gamma_{ij}$$
$$\beta_{0j} = \gamma_{00} + \mu_{0j}$$

means that the observations within owner clusters are more similar to each other than observations from different owner clusters. This finding aligns with our hypothesis that place management has a substantial impact on crime. Not accounting for place management usually inflates the influence of land use – making many land uses appear more criminogenic than they are – and ignores the practices of some owners that inflate crime.[3]

[3] How important is this 37 percent? We can provide benchmark drawing on a frequently cited study that has prompted considerable research. Sampson, Raudenbush, and Earls (1997: p. 921) reported that neighborhood factors account for 21 percent of the variation in victimizations. They attributed this to collective efficacy. Our estimate of the influence of place management on crime is a third again larger.

APPENDIX H. Estimated Coefficients of Land Use and Control Variables on Crime (with Interaction Terms) After Clustered by Owners

	All crime			Violent crime			Property crime		
	IRR	Std. Err.	z	IRR	Std. Err.	z	IRR	Std. Err.	z
Fast food	*3.49*	*2.99*	*1.46*	17.83*	13.91	3.69	*2.73*	*2.35*	*1.17*
Retail shops	2.62*	0.87	2.90	3.69*	1.21	3.96	2.93*	1.20	2.64
Restaurants	*1.68*	*0.72*	*1.22*	*1.64*	*0.82*	*0.99*	*2.10*	*0.89*	*1.75*
Apartments	3.40*	0.64	6.51	4.93*	0.85	9.21	3.19*	0.84	4.39
Hotels	*3.38*	*2.28*	*1.80*	*2.43*	*1.37*	*1.57*	*4.21*	*3.68*	*1.65*
Bars	*2.60*	*1.31*	*1.89*	20.28*	15.49	3.94	*2.76*	*1.70*	*1.65*
Car service centers	*1.08*	*0.56*	*0.15*	*1.65*	*1.14*	*0.72*	*1.27*	*0.75*	*0.40*
Schools	*0.65*	*0.46*	*-0.61*	*1.11*	*0.41*	*0.27*	*0.38*	*0.24*	*-1.55*
Offices	*2.24*	*0.96*	*1.88*	3.21*	0.94	3.97	*2.59*	*1.31*	*1.89*
Hospitals	*1.40*	*0.34*	*1.38*	*1.30*	*0.40*	*0.86*	*1.30*	*0.35*	*0.97*
Three or more family homes	1.90*	0.25	4.98	2.90*	0.47	6.58	1.74*	0.29	3.34
Warehouses	*1.30*	*0.27*	*1.28*	*1.37*	*0.40*	*1.07*	*1.46*	*0.35*	*1.55*
Two family homes	1.46*	0.13	4.13	1.57*	0.19	3.78	1.39*	0.17	2.76
Worship places	*0.99*	*0.33*	*-0.03*	0.82	0.48	-0.35	1.08	0.35	0.24
Garages	*0.69*	*0.28*	*-0.91*	*0.93*	*0.31*	*-0.22*	0.77	0.39	-0.51
Universities	1.30	1.42	0.24	0.78	0.69	-0.28	1.39	1.61	0.28
Vacant lands	0.17*	0.03	-11.56	0.38*	0.06	-5.93	0.15*	0.03	-10.80
Single-family homes	0.21*	0.03	-11.26	0.24*	0.06	-5.74	0.19*	0.03	-10.66
Concentrated disadvantage area	1.85*	0.36	3.15	2.19*	0.46	3.75	1.57*	0.25	2.78
Amount of tax paid	1.00*	0.00	5.25	1.00*	0.00	2.49	1.00*	0.00	6.52
Areal size	1.00*	0.00	6.02	1.00*	0.00	5.59	1.00*	0.00	6.19
Market total value	1.00*	0.00	3.16	1.00*	0.00	3.26	1.00*	0.00	2.36
Year	0.94*	0.00	-12.77	0.95*	0.01	-5.16	0.94*	0.00	-12.12
Interaction with Concentrated disadvantage									
Fast food	-	-	-	0.28	0.23	-1.54	-	-	-
Retail shops	2.84	1.64	1.81	2.13	1.38	1.18	3.86*	2.10	2.47
Restaurants	2.09	1.28	1.20	-	-	-	2.25	1.31	1.38
Apartments	0.56*	0.11	-2.96	0.47*	0.11	-3.28	0.68*	0.13	-2.08
Offices	0.78	0.40	-0.48	0.71	0.40	-0.61	-	-	-
Three or more family households	0.57*	0.11	-2.83	0.35*	0.10	-3.66	0.71	0.13	-1.84
Two family households	0.73	0.12	-1.85	0.58*	0.14	-2.27	0.86	0.13	-0.98
Single family households	6.26*	5.15	2.23	7.98*	2.63	6.30	5.24	7.40	1.17
Vacant lands	1.35	0.38	1.07	0.98	0.32	-0.07	1.58	0.44	1.64
Log-Likelihood	-138812.96			-15325.21			-86178.35		
Wald Chi-Square	2542.67			817.37			4450.12		
Probability > Chi-Square	0.00			0.00			0.00		

* Statistically significant, p-value < 0.05.

Coefficients in italics were statistically significant in Table 3 but not in Appendix H.

Number of properties analyzed (N_1=284,318); Number of property owners analyzed (N_2=26,686).

APPENDIX I. Estimated Coefficients of Land Use and Control Variables on Crime After Clustered by Owner

	All crime			Violent crime			Property crime		
	IRR	Std. Err.	z	IRR	Std. Err.	z	IRR	Std. Err.	z
Fast food	4.02	3.28	1.71	17.84*	14.19	3.62	3.29	2.71	1.45
Retail shops	3.39*	1.07	3.88	4.47*	1.27	5.28	3.92*	1.58	3.38
Restaurants	2.14*	0.80	2.03	1.84	0.89	1.25	2.69*	1.02	2.60
Apartments	3.01*	0.56	5.94	4.24*	0.75	8.23	2.90*	0.74	4.17
Hotels	3.40	2.30	1.81	2.44	1.38	1.58	4.25	3.73	1.65
Bars	2.64	1.37	1.88	18.25*	13.76	3.85	2.75	1.76	1.58
Car service centers	1.16	0.57	0.29	1.67	1.17	0.74	1.37	0.78	0.56
Schools	0.67	0.47	-0.57	1.14	0.41	0.37	0.38	0.24	-1.51
Offices	2.16*	0.83	2.01	3.04*	0.87	3.89	2.63	1.33	1.91
Hospitals	1.37	0.33	1.31	1.27	0.40	0.78	1.28	0.34	0.93
Three or more family homes	1.65*	0.21	3.96	2.26*	0.36	5.18	1.57*	0.25	2.87
Warehouses	1.36	0.28	1.48	1.47	0.43	1.32	1.50	0.37	1.66
Two family homes	1.37*	0.13	3.40	1.41*	0.17	2.87	1.34*	0.16	2.48
Worship places	0.99	0.33	-0.04	0.82	0.47	-0.34	1.07	0.35	0.21
Garages	0.71	0.29	-0.84	0.96	0.32	-0.13	0.79	0.40	-0.47
Universities	1.27	1.38	0.22	0.78	0.71	-0.27	1.39	1.60	0.29
Vacant lands	0.18*	0.03	-11.68	0.39*	0.06	-6.15	0.16*	0.03	-10.73
Single-family homes	0.32*	0.06	-6.02	0.24*	0.06	-5.85	0.27*	0.08	-4.61
Concentrated disadvantage area	1.63*	0.27	3.01	1.61*	0.28	2.79	1.61*	0.31	2.51
Amount of tax paid	1.00*	0.00	5.17	1.00*	0.00	2.41	1.00*	0.00	6.55
Areal size	1.00*	0.00	6.04	1.00*	0.00	5.61	1.00*	0.00	6.20
Market total value	1.00*	0.00	3.60	1.00*	0.00	3.15	1.00*	0.00	3.85
Year	0.94*	0.00	-12.62	0.95*	0.01	-5.12	0.94*	0.00	-12.02
Log-Likelihood	-139331.20			-15368.88			-86495.92		
Wald Chi-Square	1389.35			781.67			1443.03		
Probability > Chi-Square	0.00			0.00			0.00		

* Statistically significant, p-value < 0.05.

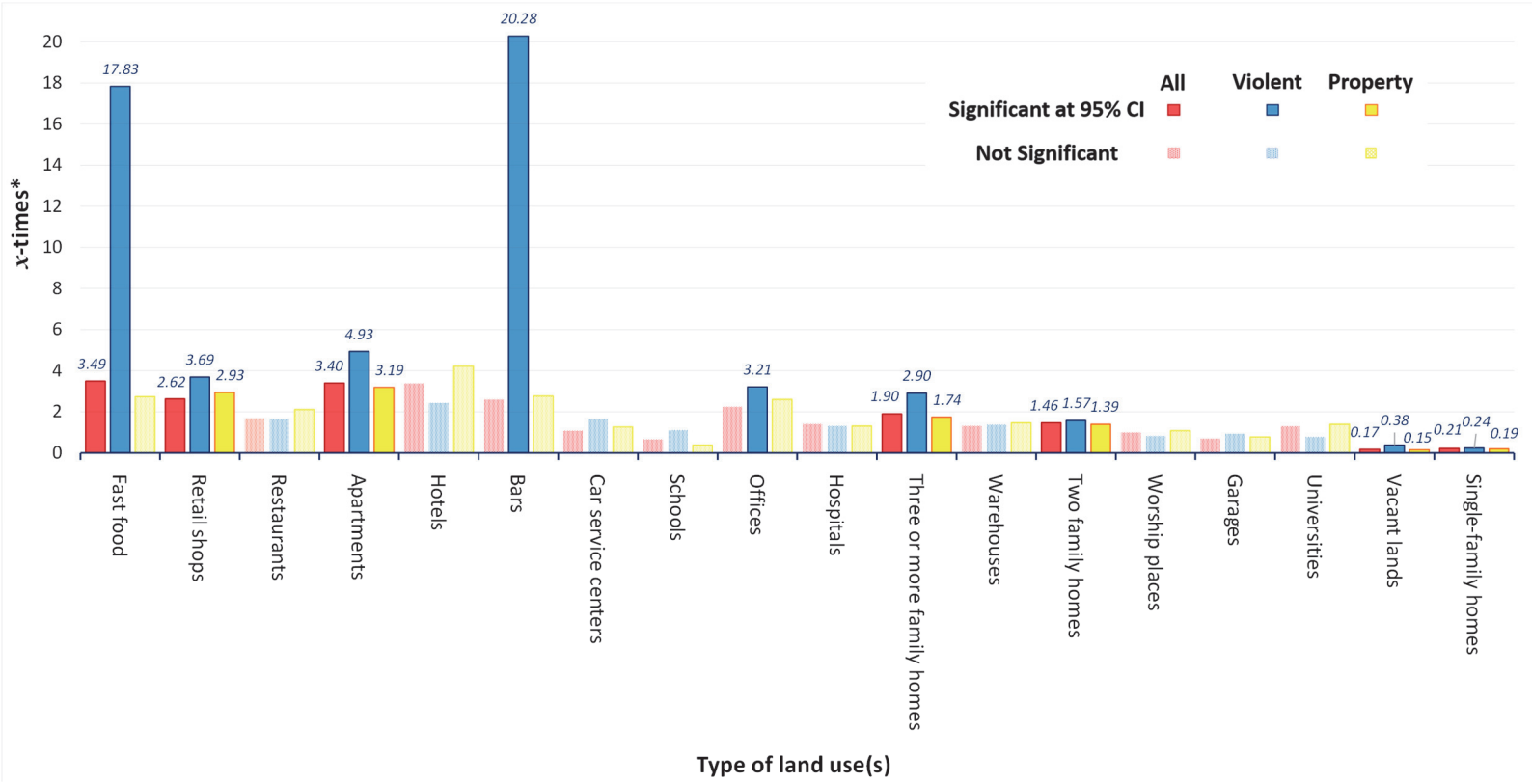
Number of properties analyzed (N_1=284,318); Number of property owners analyzed (N_2=26,686).

APPENDIX J. Variance Inflation Factors of Land Use and Control Variables

Variables	Variance Inflation Factor (VIF)
Fast food	1.00
Retail shops	1.01
Restaurants	1.00
Apartments	1.06
Hotels	1.00
Bars	1.00
Car service centers	1.00
Schools	1.01
Offices	1.01
Hospitals	1.01
Three or more family homes	1.02
Warehouses	1.01
Two family homes	1.07
Worship places	1.01
Garages	1.02
Universities	1.00
Vacant lands	1.08
Single-family homes	1.04
Concentrated disadvantage area	1.02
Amount of tax paid	1.01
Areal size	1.02
Market total value	1.03
Year	1.00

APPENDIX K. Risk of crime (in x-times) across 18 types of land uses after controlling place management*

*Values greater than 1 are riskier than public places, while values less than 1 are safer or less risky.



Once we synthesize our findings in Figures 1, 2 and 3, the figure above illustrates how different land uses experience relative risks (in x-times) compared to public places. Specifically, fast food restaurants (3.5 times risky in all crime (AC), 17.8 times risky in violent crime (VC)), retail shops (2.6 times risky in AC, 3.7 times risky in VC, 3 times risky in Property crime (PC)), apartment complex (3.4 times in AC, 5 times risky in VC, 3.2 times risky in PC), bars (20 times risky in VC), offices (3.2 times risky in VC), three or more family homes (1.9 times risky in AC, 2.9 times risky in VC), and two family homes (about 1.5 times risky in AC, VC, and PC) experience significantly higher risk of crime relative to public places. On the other hand, vacant lands and single-family homes experience significantly lower risk. However, full restaurants, hotels, car service centers, schools, hospitals, warehouses, worship places, garages, and universities do not show significant difference relative to the risk at public places.

APPENDIX L. Estimated Coefficients of Land Use and Control Variables on Crime After Clustered by Owner (reference variable: Single-Family homes)

	All crime			Violent crime			Property crime		
	IRR	Std. Err.	z	IRR	Std. Err.	z	IRR	Std. Err.	z
Fast food	10.26*	8.91	2.68	77.20*	63.19	5.31	9.91*	8.76	2.59
Retail shops	7.78*	2.55	6.26	16.04*	6.31	7.05	10.69*	4.67	5.42
Restaurants	4.98*	2.16	3.71	6.79*	3.88	3.35	7.71*	3.56	4.43
Apartments	9.98*	2.01	11.43	21.38*	5.92	11.06	11.47*	3.54	7.91
Hotels	12.25*	8.43	3.64	13.56*	7.84	4.51	21.15*	19.36	3.33
Bars	12.29*	6.27	4.91	89.48*	75.63	5.32	13.51*	9.41	3.74
Car service centers	3.43*	1.74	2.43	7.44*	5.69	2.63	4.83*	2.90	2.63
Schools	2.25	1.26	1.44	5.42*	2.26	4.05	1.41	0.79	0.61
Offices	6.56*	2.58	4.77	13.86*	4.72	7.73	9.55*	5.32	4.05
Hospitals	3.83*	1.06	4.83	5.01*	1.84	4.38	4.36*	1.47	4.36
Three or more family households	5.59*	1.02	9.46	12.59*	3.52	9.07	6.27*	1.65	6.99
Warehouses	4.49*	1.09	6.17	8.21*	3.16	5.46	5.72*	1.85	5.39
Two family households	4.28*	0.73	8.49	6.79*	1.78	7.32	5.02*	1.24	6.54
Worship places	3.12*	1.18	2.99	4.39*	2.65	2.45	4.02*	1.59	3.53
Garages	2.22*	0.74	2.40	4.61*	1.61	4.38	3.01*	1.37	2.42
Universities	4.01	4.69	1.18	3.33	2.92	1.38	5.03	5.92	1.37
Vacant lands	0.50*	0.10	-3.42	1.61	0.44	1.73	0.59	0.16	-1.93
Public places	2.86*	0.54	5.53	4.21*	1.07	5.64	3.55*	0.90	5.00
Concentrated disadvantage area	0.88	0.63	-0.18	2.57*	0.74	3.26	1.48	1.01	0.58
Amount of tax paid	1.00*	0.00	5.56	1.00*	0.00	2.37	1.00*	0.00	6.98
Areal size	1.00*	0.00	6.05	1.00*	0.00	5.57	1.00*	0.00	6.20
Market total value	1.00*	0.00	3.31	1.00*	0.00	3.33	1.00*	0.00	3.45
Year	0.94*	0.00	-12.68	0.95*	0.01	-5.16	0.94*	0.00	-12.09
Log-Likelihood	-138704.98			-15306.52			-86158.35		
Wald Chi-Square	1934.82			10903.31			2048.93		
Probability > Chi-Square	0.00			0.00			0.00		

* Statistically significant, p-value < 0.05.

Estimated coefficients of the interaction terms between land use and concentrated disadvantages are also available by direct request to the authors.

APPENDIX M. Summary of IRR Changes from Unclustered to Clustered (percent of 18 land uses and number)

	All Crimes		Violent Crimes		Property Crimes	
IRR	Unclustered	Clustered	Unclustered	Clustered	Unclustered	Clustered
Significant	94% (17)	33% (6)	89% (16)	50% (9)	83% (15)	33% (6)
Declined	-	83% (15)	-	83% (15)	-	78% (14)
Increased	-	17% (3)	-	17% (3)	-	22% (4)