Green Neighbors, Greener Neighborhoods: Peer Effects in Green Home Investments

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1. Motivation and Research Question

Investments in green home technologies are crucial:

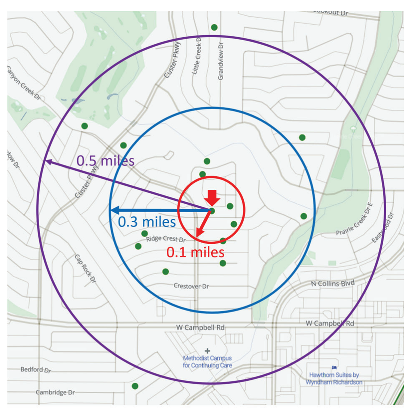
- A viable strategy in managing GHG emissions (20% from the residential sector)
- Large potential, as US current uptake is low (2%)
- Informational issues limit wider adoption (Matisoff et al., 2016; Howarth and Andersson, 1993)

⇒ Consequently, already-adopting neighbor peers are a relevant source of information

Research question: Evaluate the causal effects of green neighbor peers on the decision of households to invest in their homes certifying them green.

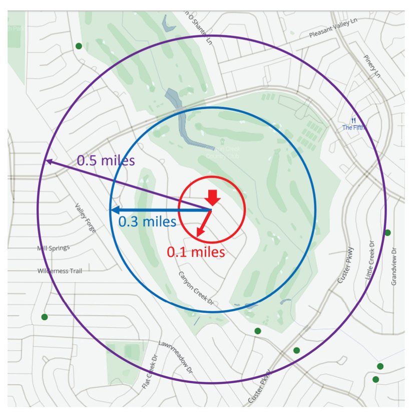
2. Nearest-Neighbor Research Design

Research Design:
Estimate the effect of green neighbors within 0.1 miles, conditional on such neighbors within 0.3 and 0.5 miles.



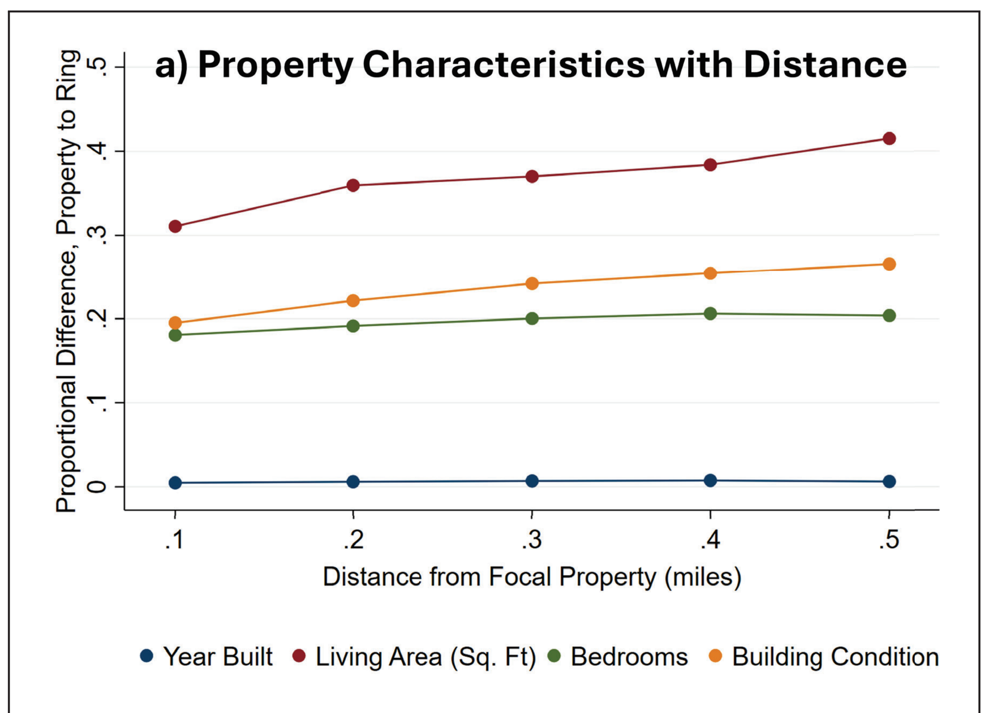
Green

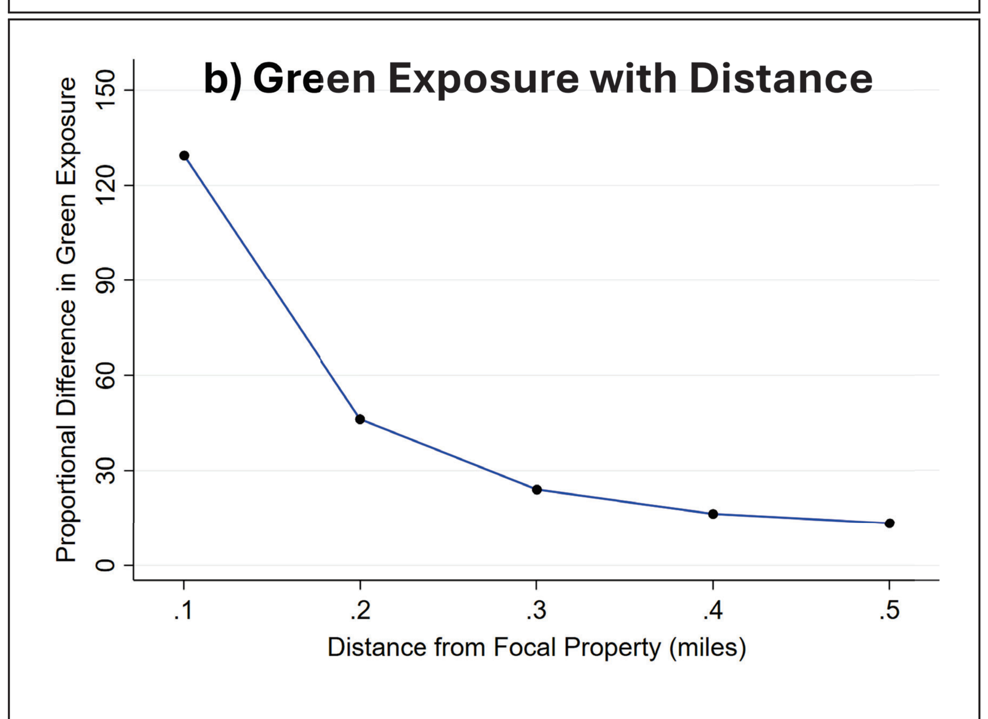
Identification Assumption:
1) Neighbors within 0.5 miles are quasi-randomly assigned
2) Interactions among hyper-local neighbors are more likely

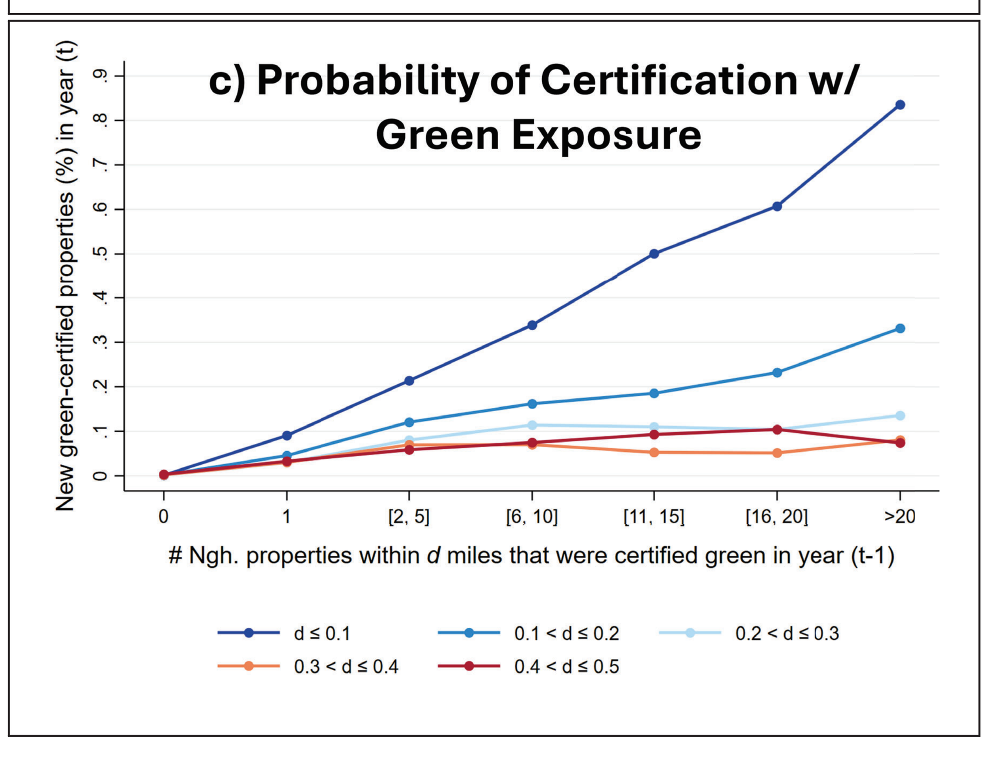


Non-green

Diagnostic Tests and Key Result:
Fig a): Property characteristics are similar
Fig b): Green exposure varies with distance
Fig c): The probability of certification increases with green exposure from closer neighbors







3. Theoretical Framework

Model: A discrete choice model under social interactions (Brock and Durlauf, 2001) with information costs

Key ingredient: Information costs reduce with the number of adopting peers.

Key prediction: The probability of a household making green home investments is:

$$Pr(g_i = 1) = \frac{1}{1 + exp[-(\Pi_i(\cdot) + \delta p_i - C_i(\cdot) - F_1 - F_2 + (\nu_1 + \nu_2 K_a) m_i)]}.$$

Implications:

- The probability of adoption increases with the number of green neighbors.
- Peer effects are stronger in areas where green homes receive additional benefits.
- Peer effects do not depend on green preferences.
- Individual optimization leads to below-optimum adoptions. Under low peer effect environment, allocating more subsidies to areas with stronger peer effects can reduce the inefficiency.

4. Baseline Results

One additional green neighbor within 0.1 miles increases the probability of a household making green home investments by **1.58x** within a year.

	Outcome: Green (=10,000)			
	(1)	(2)	(3)	(4)
$N_G(\leq 0.1$ mi)	0.69***	0.33***	0.37***	0.38***
	(0.06)	(0.05)	(0.05)	(0.05)
$N_G(\leq 0.3$ mi)		0.27***	0.23***	0.22***
		(0.02)	(0.02)	(0.02)
$N_G(\leq 0.5$ mi)		0.08***	0.06***	0.06***
		(0.01)	(0.01)	(0.01)
Constant	0.32***	0.21***	0.23***	0.23***
	(0.01)	(0.01)	(0.01)	(0.01)
Marginal Effect to Hazard Rate				
$N_G(\leq 0.1$ mi)	2.18***	1.58***	1.78***	1.82***
	(0.19)	(0.28)	(0.27)	(0.27)
Fixed effects	N	N	Zip code, YQ	Zip code × YQ
R^2 (Adj.)	0.0010	0.0014	0.0021	0.0033
Observations	1,037,652,080	1,037,652,080	1,037,652,076	1,037,641,505

5. Mechanism: Information Transmission

Peer Effects and Multi-Property Owners (MPO)

The effects extend to secondary properties of MPOs.

	Outcome: Secondary Property Green (=10,000)			
Secondary Property-Primary Nbrs Similarity:	[Top Quartile]		[Bottom Quartile]	
	(1)	(2)	(3)	(4)
Primary to Secondary Distance	>20 mi	>50 mi	>20 mi	>50 mi
$N_G(\leq 0.1$ mi$)_{\text{Primary Home}}$	0.010**	0.010**	-0.001	-0.001
	(0.00)	(0.00)	(0.00)	(0.00)
$N_G(\leq 0.1$ mi$)_{\text{Secondary Property}}$	0.073*	0.080*	0.035	0.036*
	(0.04)	(0.05)	(0.02)	(0.02)
0.3- & 0.5-mi $N_{G,\text{ Primary Home}}$	Y	Y	Y	Y
0.3- & 0.5-mi $N_{G,\text{ Secondary Property}}$	Y	Y	Y	Y
Primary zip code FE	Y	Y	Y	Y
Secondary zip code FE	Y	Y	Y	Y
YQ FE	Y	Y	Y	Y
R^2 (Adj.)	0.1175	0.1154	0.1039	0.0989
Observations	16,228,739	15,335,946	24,882,976	24,660,686

Peer Commonalities in Green Investments

Green households are more likely to choose the same green certificate, similar investment specification, and same lenders as their 0.1-mile green neighbors.

	Program Similarity		Investment Similarity		Lender Similarity	
Outcome:	𝟙(Same Program)		Text Cosine Similarity		𝟙(Same Lender)	
	(1)	(2)	(3)	(4)	(5)	(6)
Sample:	[All Prog]	[Ex Top Prog]	[Certificate]	[Bldg. Permit]	[All Lender]	[Ex Top 3 Lender]
𝟙(Dist. ≤ 0.1 mi)	0.005***	0.011***	0.020***	0.056**	0.130***	0.141***
	(0.00)	(0.00)	(0.00)	(0.02)	(0.01)	(0.01)
Focal tenure FE	Y	Y	Y	Y	Y	Y
Focal zipcode × YQ FE	Y	Y	Y	Y	Y	Y
R^2 (Adj.)	0.5227	0.5929	0.7093	0.2619	0.3473	0.3493
Observations	7,338,920	787,273	90,971	9,138,633	230,792	200,320

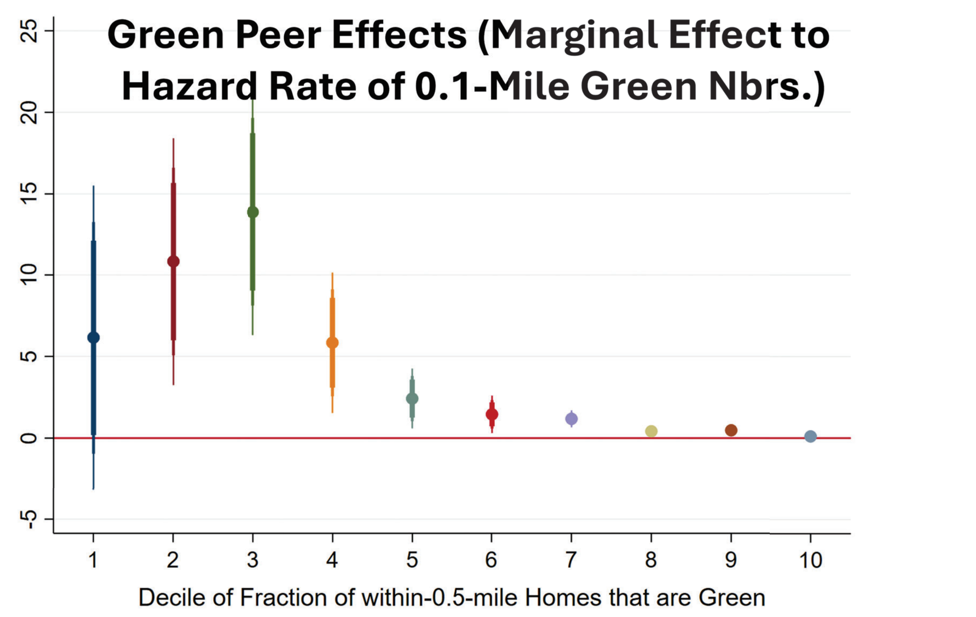
Effect Heterogeneity by Strength of Local Community Interactions

The green-peer effects are more pronounced in areas where local community interactions are stronger.

	Outcome: Green (=10,000)			
	(1)	(2)	(3)	(4)
Characteristic $\mathbb{X}$:	Social Connectedness	Support Ratio	Social Capital	% Investment Properties
[Median of $\mathbb{X}$ calculated at:]	[zip code]	[zip code]	[county]	[zip code × yq]
𝟙(High $\mathbb{X}$) × $N_G(\leq 0.1$ mi)	0.387*	0.401***	0.537***	-0.190*
	(0.22)	(0.13)	(0.11)	(0.11)
$N_G(\leq 0.1$ mi)	0.445***	0.438***	0.360***	0.554***
	(0.05)	(0.05)	(0.05)	(0.09)
𝟙(High $\mathbb{X}$)			-0.111**	0.074***
			(0.04)	(0.03)
Level: 0.3- & 0.5-mi N_G	Y	Y	Y	Y
Interaction: 0.3- & 0.5-mi N_G	Y	Y	Y	Y
FE: zip code and YQ	Y	Y	Y	Y
R^2 (Adj.)	0.0024	0.0023	0.0021	0.0021
Observations	937,546,288	1,018,429,013	1,037,652,076	1,037,652,076

6. Hump-Shaped Peer Effect

The relation between the strength of peer effects and the level of adoption is hump shaped.



7. Heterogeneity by Financial Benefits

The green-peer effects are stronger in areas where green homes enjoy higher financial benefits.

	Outcome: Green (=10,000)		
	(1)	(2)	(3)
Benefit ($\mathbb{B}$) in terms of:	House Prices	Electricity Prices	Incentives
𝟙($\mathbb{B}$ exists) × $N_G(\leq 0.1$ mi)	0.668***	0.339***	0.970***
	(0.24)	(0.10)	(0.10)
$N_G(\leq 0.1$ mi)	0.337***	0.123*	0.359***
	(0.04)	(0.06)	(0.06)
𝟙($\mathbb{B}$ exists)	0.155***	-0.081***	-0.162***
	(0.06)	(0.03)	(0.04)
Level: 0.3- & 0.5-mi N_G	Y	Y	Y
Interaction: 0.3- & 0.5-mi N_G	Y	Y	Y
FE: zip code and YQ	Y	Y	Y
R^2 (Adj.)	0.0022	0.0015	0.0023
Observations	303,576,068	874,272,556	983,212,581

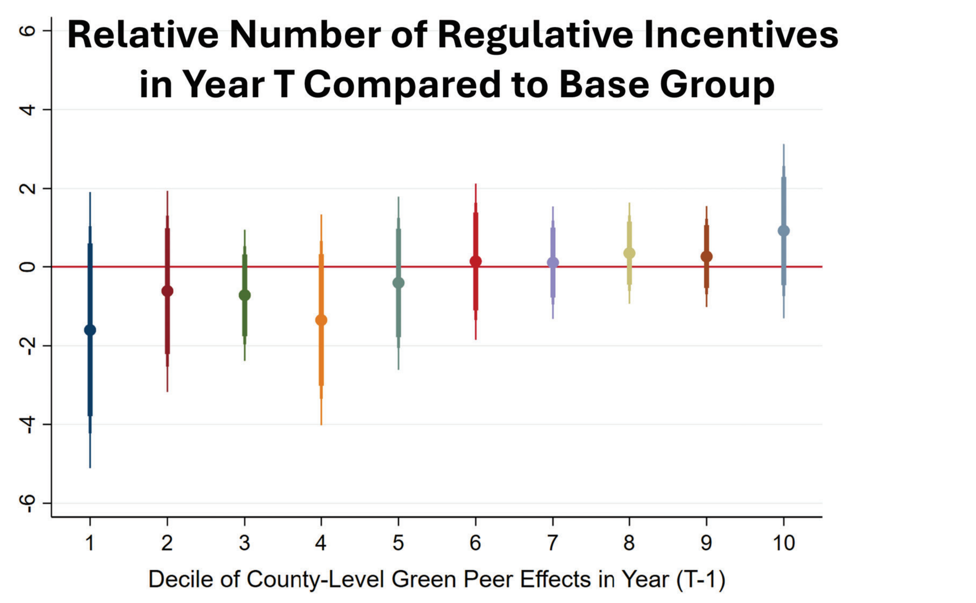
8. Heterogeneity by Green Preferences

Peer effects remain similar across counties with varying degrees of households' green preferences.

Outcome:	% Green Home		Green (=10,000)	
	(1)	(2)	(3)	(4)
% Climate Worried	0.047***			
	(0.01)			
# EV per HH		1.314*		
		(0.69)		
𝟙(High % Climate Worried) × $N_G(\leq 0.1$ mi)			-0.018	
			(0.12)	
𝟙(High # EV per HH) × $N_G(\leq 0.1$ mi)				-0.108
				(0.14)
$N_G(\leq 0.1$ mi)			0.460***	0.773***
			(0.09)	(0.10)
Level: 𝟙(High $\mathbb{X}$)	-	-	Y	Y
Level: 0.3- & 0.5-mi N_G	-	-	Y	Y
Interaction: 0.3- & 0.5-mi N_G	-	-	Y	Y
Housing mkt. & demog. controls	Y	Y	-	-
Fixed effects	County, Year	Zip code, Year	Zip code, YQ	Zip code, YQ
Clustering level	County	Zip code	Zip code × YQ	Zip code × YQ
Observation unit	County	Zip code	Property	Property
R^2 (Adj.)	0.8247	0.7970	0.0020	0.0020
Observations	11,233	48,596	821,323,588	348,127,621

9. Policy Implications

The number of regulatory incentives are not higher in areas characterized by stronger peer effects.



Takeaway: The model indicates that re-aligning regulatory incentives with the strength of green-peer effects may reduce inefficiencies in green adoptions.

Key Findings and Conclusions

- This is the first paper to document causal peer effects in household green home investments, and the first to utilize the nearest-neighbor design on a national scale.
- One additional green neighbor within 0.1 miles increases the probability of a household investing in green home technologies by **1.58x**.
- The mechanism for the peer effect is information transmission.
- Financial benefits play a larger role than the green preference in shaping the green peer effect.