

FROM VACANCY TO VERDANCY? THE IMPACT OF LAND OPTIONS ON THE TIMING OF VACANT LOT INVESTMENT

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INTRODUCTION



- Land vacancy is a persistent phenomenon leading to socioeconomic issues
 - ▶ A cost-effective anti-blight solution: vacant lot greening
- If we relax the zoning code to allow for more land options, to what extent can we stimulate investment on vacant lots and reduce vacancy?

THIS STUDY...



- compiles a lot-level time-to-event data set to track changes in land uses
 - ▶ tracks **the life cycle of a vacant lot**: entry/exit of vacancy status
 - ▶ extends a Samuelson-McKean real options model to multiple uses
 - ▶ tests predictions through a greening program (*Philadelphia LandCare*)
- evaluates the impact of endowing vacant lots with the option of greening
 - ▶ A vacant lot is modeled as a call option with two investment options
 - ★ “**housing**”: develop vacant lots into residential homes
 - ★ “**greening**”: convert vacant lots into gardens and reserve the option of being redeveloped into **housing**

LIFE CYCLE OF A VACANT LOT

CONTROL VS TREATMENT



Control: vacant Lots with a single land use of housing



Vacant Lot

Developed
into



Housing Lot

Treatment: vacant Lots endowed with the greening option



Housing Lot

Developed
into



Vacant Lot

Developed
into



Greened Lot

- Introducing the greening option expedites initial investment on vacant lots
 - ▶ Time in vacancy is reduced by about 50%
 - ▶ Efficacy of vacant lot greening on investment depends on neighborhoods
- Investment on vacant lots is consistent with real options arguments
 - ▶ Housing investment depends on uncertainty and growth rate
 - ▶ but... greening investment shows insignificant effects
 - ★ Reduced irreversibility of initial investment plays a role

VACANT LOT GREENING: LANDCARE PROGRAM



- A citywide community development program in Philadelphia since 1996, administered by the Pennsylvania Horticultural Society (PHS)
 - ▶ **Goal:** offer a cost-effective and scalable solution to urban blight
 - ▶ **Status quo:** 12,000+ lots greened (>10 Mn sq.ft.); 400/year added;
- Vacant lot greening creates amenity value
 - ▶ increased property values; stress reduction & health improvement; decreased crime, violence & drug possession; urban heat mitigation
- Greened lots are intended to be temporary by design, reserving the redevelopment option
 - ▶ 10-15% redeveloped into housing, commercials, or permanent green space

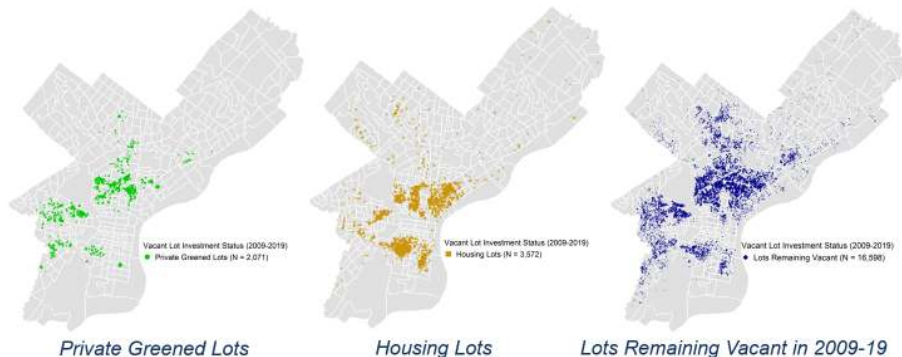
“CLEAN AND GREEN” REMEDIATION



- remove trash and debris
- grade the land
- plant grass and some trees
- install low wooden post-and-rail fences around lot's perimeter
- Cost involves installation (\$1/sq.ft) and routine maintenance (\$350/year)
 - ▶ A typical lot (1,000 sq.ft.) incurs \$400/year (at 5% discount rate)

WHERE DOES INVESTMENT OCCUR?

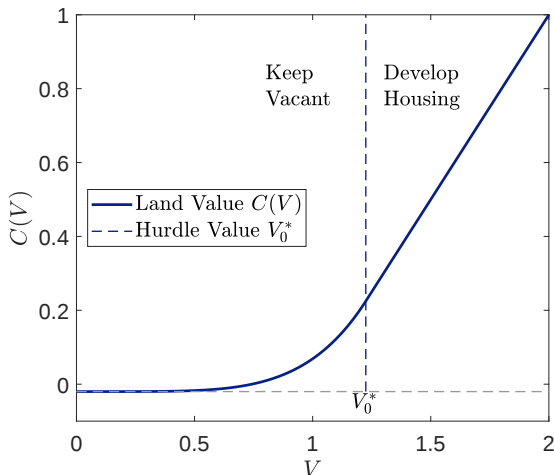
GREENING VS HOUSING



- Greened lots are more concentrated in less favorable areas
 - ▶ Higher uncertainty, lower price & growth, lower income, higher vacancy
- Vacant lots selected for greening differ from those developed into housing
 - ▶ Selection adjustment: propensity score matching based on block group attributes to create a matched sample

LAND AS A PERPETUAL CALL OPTION

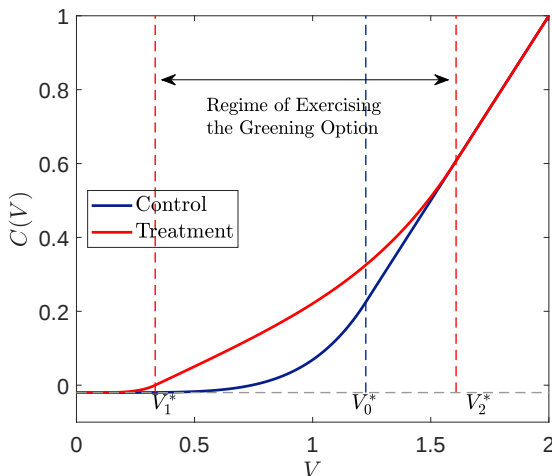
LAND VALUE & HURDLE VALUE (SAMUELSON-McKEAN FRAMEWORK)



- Land value $C(V)$ depends on the price level of housing V
- Hurdle value V_0^* is the min price level of housing investment

LAND AS A PERPETUAL CALL OPTION

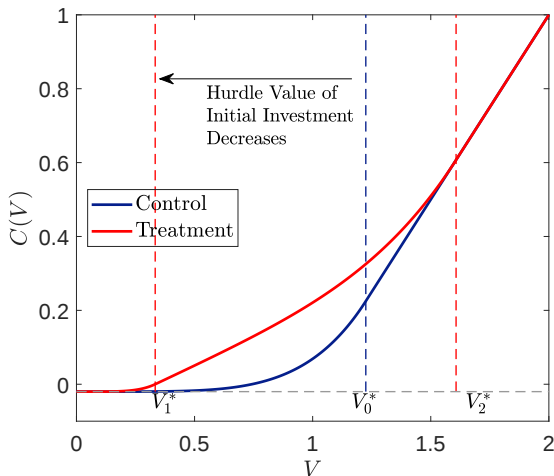
CONTROL VS TREATMENT



- Treatment: relax zoning code by endowing vacant lots with the greening option
- With treatment, a new regime of exercising the greening option arises

LAND AS A PERPETUAL CALL OPTION

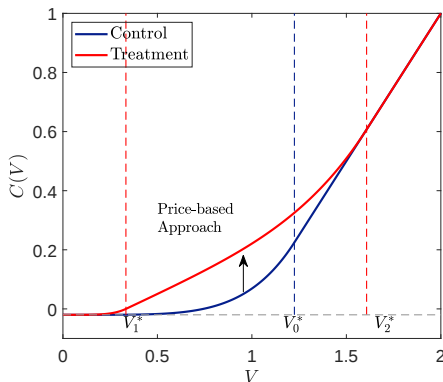
CONTROL VS TREATMENT



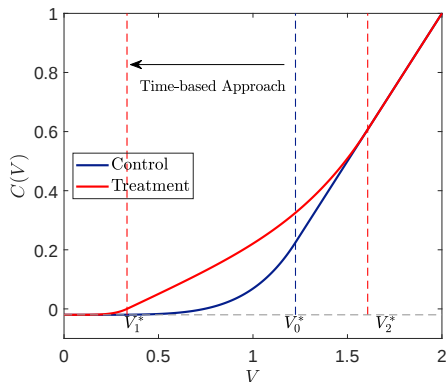
- With treatment, hurdle value decreases and investment arrives sooner

IDENTIFY REAL OPTIONS EFFECTS

PRICE-BASED VS TIME-BASED APPROACH



(a) Examine Price Variation



(b) Explore Time Variation

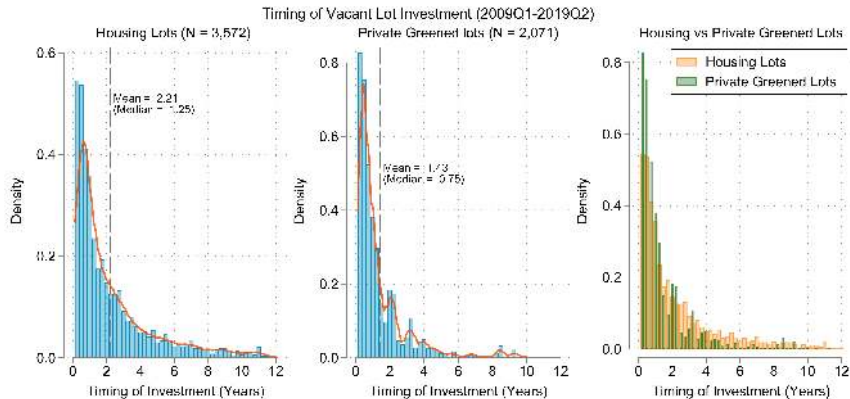
- Time-based approach makes analyzing a larger set of land investment possible, including those without land transfers and observed prices

HOW TIMING OF INVESTMENT IS MEASURED



- Compile a lot-level dataset (2009-19) to track land use changes in Philadelphia
 - ▶ Vacant Lots from code violation data records **entry** of vacancy status
 - ★ Focus on lots subject to vacancy violation w/o housing structure
 - ▶ Greened Lots in the LandCare program records **exit** of vacancy status
 - ★ Focus on private lots to rule out the landownership impact
 - ▶ Housing Lots from building permit data records **exit** of vacancy status
 - ★ Lots receiving construction permits on erecting an entire structure
- Focus on privately owned vacant lots to rule out the impact of landownership

TIMING OF INVESTMENT: HOUSING VS GREENING



- Shorter investment timing for vacant lots treated with greening options
 - ▶ Housing: 2.2 Years vs Greening: 1.4 years

MODEL INVESTMENT TIMING OF VACANT LOTS

AFT SURVIVAL MODEL



- Estimate an accelerated failure time (AFT) survival model

$$\ln(T_{iq}) = \begin{bmatrix} \theta_0 & +\theta_{\sigma 1} \ln \sigma_{V,j(i)}^2 & +\theta_{p1} E[p_{j(i)}] & +\theta_{r1} r_{V,j(i)} \\ & +\theta_{\sigma 2} (\ln \sigma_{V,j(i)}^2)^2 & +\theta_{p2} (E[p_{j(i)}])^2 & +\theta_{r2} (r_{V,j(i)})^2 \end{bmatrix} \\ + X_i^B \Pi^B + \tau_{year(q)} + v_{iq}$$

- T_{iq} is timing of investment of lot i developed in quarterly date q
 - Uncertainty $\ln \sigma_{V,j(i)}^2$, price level $E[p_{j(i)}]$, growth rate $r_{V,j(i)}$
 - Block-group attributes from ACS data in X_i^B (household income, black/Hispanic share, vacancy rate, population)
 - Investment year fixed effects $\tau_{year(q)}$ capture time-varying financing cost
- Error term v_{iq} depends on the survival distribution assumption
 - exponential, Weibull, log normal (best), generalized Gamma

REAL OPTIONS VARIABLES (1/2)

UNCERTAINTY, PRICE LEVEL, GROWTH RATE



- Built on Cunningham (2007), I create a panel of quality-adjusted price index

$$\ln(P_{ijq}) = X_{ijq}^H B_{jq} + \sum_{t=0}^7 \tau_{q-t} + \epsilon_{ijq}, \text{ for } q-7 \leq \hat{q}(i) \leq q$$

- ▶ P_{ijq} is the price of sale i in ZIP code j in quarter date q
 - ▶ X_{ijq}^H is housing attributes; τ_q is the quarterly-date fixed effects
 - ▶ A regression use sales within an 8-quarter rolling window
- Using Zillow's housing sales data from 2001Q4 to 2019Q2 in Philadelphia, 3,266 price equations are estimated (71 quarters·46 ZIP codes)

REAL OPTIONS VARIABLES (2/2)

UNCERTAINTY, PRICE LEVEL, GROWTH RATE



- Estimate a price index model, evaluated at average attributes by ZIP code

$$p_{jq} = \beta_{0j} + \beta_{1j}p_{j,q-4} + e_{jq}, \text{ where } p_{jq} \equiv \bar{X}_j^H \hat{B}_{jq} + \hat{\tau}_q$$

- Uncertainty is the four-quarter average of the squared deviation of prediction errors from the local mean

$$\sigma_{V,jq}^2 \equiv \frac{1}{4} \sum_{t=1}^4 (\hat{e}_{j,q-t} - \bar{e}_{jq})^2, \hat{e}_{j,q-t} \equiv p_{jq} - \hat{\beta}_{0j} - \hat{\beta}_{1j}p_{j,q-4}, \bar{e}_{jq} \equiv \frac{1}{4} \sum_{t=1}^4 \hat{e}_{j,q-t}$$

- Price level is the one-year-ahead predicted log price

$$E[p_{j,q+4}] \equiv \hat{\beta}_{0j} + \hat{\beta}_{1j}p_{j,q}$$

- Price growth is the real price growth rate from a year ago

$$r_{V,jq} \equiv p_{jq} - p_{j,q-4}$$

- Hypothesis 1: Vacant lot investment would occur sooner, if
 - ▶ uncertainty decreases; price level increases; growth rate increases
- Hypothesis 2: Timing of greening investment occurs sooner than that of housing investment
 - ▶ The greening option reduces irreversibility of initial investment
- Hypothesis 3: Compared to housing, greening is associated with
 - ▶ a less positive (less sensitive) effect of uncertainty on investment timing
 - ▶ the same effect of price level
 - ▶ a less negative (less sensitive) effect of growth rate

TIMING OF HOUSING INVESTMENT IS CONSISTENT WITH PREDICTIONS ON UNCERTAINTY AND GROWTH RATE



Marginal Effects of a One-SD Increase on the Log Timing of Investment

<i>Housing Lots vs Private Greened Lots</i>	<i>Housing Market Factors in the Long Run</i>		<i>Housing Market Factors at Investment</i>	
	(1) Unweighted Sample	(2) PS Matched Sample	(3) Unweighted Sample	(4) PS Matched Sample
Lot Indicator				
Private Greened Lots (Base: Housing Lots)	-0.307*** (0.042)	-0.498*** (0.061)	-0.271*** (0.042)	-0.455*** (0.058)
Log Price Uncertainty				
Housing Lots	0.128*** (0.026)	0.090** (0.043)	0.072*** (0.022)	0.061** (0.031)
Private Greened Lots	0.052* (0.030)	0.044 (0.040)	-0.013 (0.020)	-0.016 (0.028)
Log Price Level				
Housing Lots	-0.044 (0.036)	-0.064 (0.097)	-0.002 (0.028)	-0.066 (0.070)
Private Greened Lots	0.031 (0.061)	-0.050 (0.068)	-0.004 (0.039)	-0.017 (0.036)
Price Growth Rate				
Housing Lots	-0.033 (0.025)	-0.141** (0.062)	-0.033 (0.026)	-0.184*** (0.057)
Private Greened Lots	-0.014 (0.038)	0.016 (0.046)	0.102*** (0.033)	0.094** (0.039)
Log Lot Size				
Housing Lots	0.058** (0.026)	0.127** (0.064)	0.074*** (0.025)	0.103* (0.063)
Private Greened Lots	0.050 (0.033)	0.063* (0.037)	0.065** (0.032)	0.091*** (0.035)

ENDOWING VACANT LOTS WITH THE GREENING OPTION LOWERS INVESTMENT TIMING BY 50%



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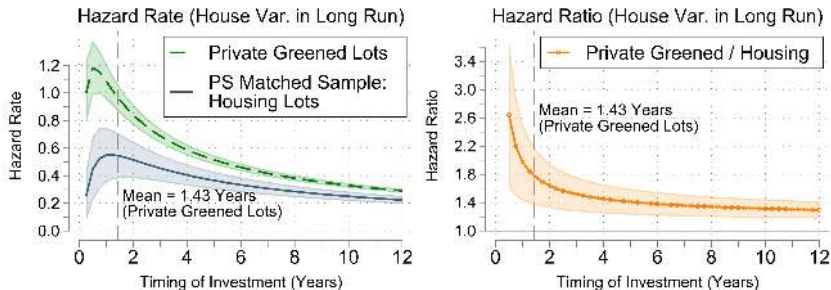
GREENING SHOWS WEAKENED REAL OPTIONS EFFECTS THAN HOUSING



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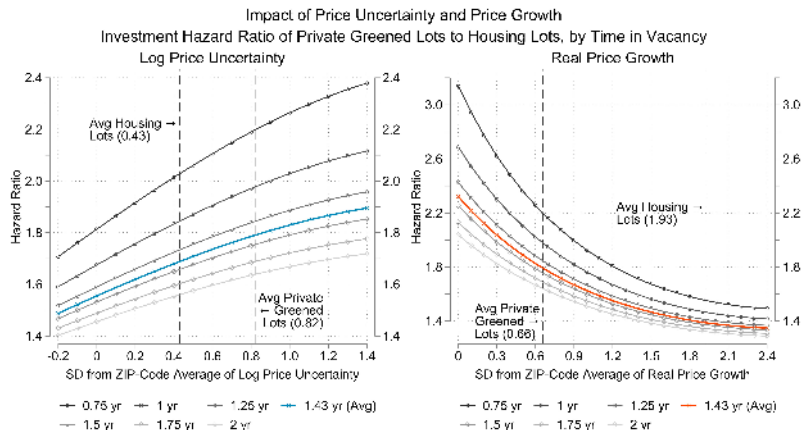
Timing of Vacant Lot Investment: Hazard Rate by Lot Type and Hazard Ratio Evaluated at the Mean Characteristics of Private Greened Lots



- Time in vacancy (or timing of investment) is a state variable
- Hazard ratio is comparable to average treatment on the treated (ATET)
- With the greening option, investment hazard increases by 80%

NEIGHBORHOOD ATTRIBUTES MATTER

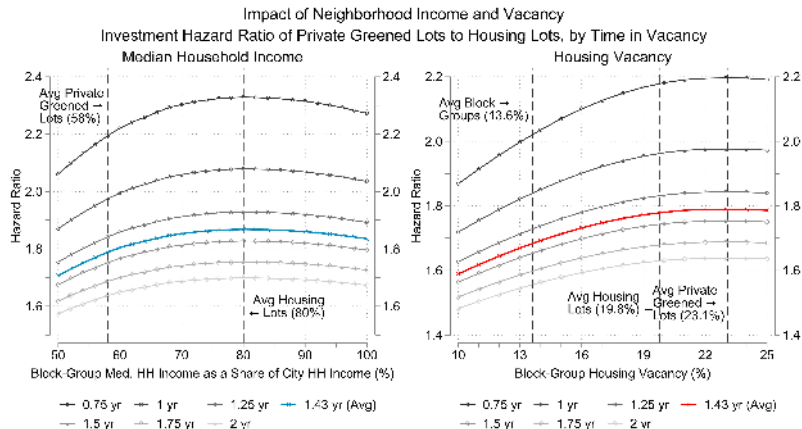
UNCERTAINTY AND GROWTH RATE



- Greater hazard ratios in high-uncertainty and low-growth neighborhoods $\Rightarrow$ stronger treatment effects

NEIGHBORHOOD ATTRIBUTES MATTER

HOUSEHOLD INCOME AND VACANCY



- Greater hazard ratios in moderately lower household income and high-vacancy neighborhoods $\Rightarrow$ stronger treatment effects



- Vacant lot greening can reduce land vacancy through a real options channel
 - ▶ Relaxing zoning code can create community value
 - ▶ I do not find support for the alternative explanation that greening reduces vacancy by stimulating housing investment nearby
- Neighborhood attributes matter to the efficacy of the program, suggesting rooms for efficiency improvement
 - ▶ This matters a lot to a city like Philadelphia, due to limited budget for community development (2 – 3 Million dollars/year)
 - ▶ The community development model can benefit other legacy cities, such as Baltimore, Detroit, Cleveland, etc.



Thank You!

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