Property Tax Sales, Private Capital, and Gentrification in the U.S.

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Property tax system and distressed housing markets are linked

- Local govts. in U.S. rely on property tax revenues to fund public goods and services
- Govt. has **recourse** and places super senior lien on delinquent properties
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- **Tax sales:** forced sales resulting from severely delinquent local taxes
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  - Other types of forced sales: mortgage foreclosure, estate, and bankruptcy auctions
- Tax authority charges interest, sends reminders to property owner, and finally sells claims to investors at (semi-)annual auctions to recoup lost revenues
  - Surplus revenues generated by auction but still sold for pennies on dollar
  - Entity who redeems the debt has low-cost opportunity to acquire property
  - $\implies$ **opportunistic developers** enter new neighborhoods

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Average unredeemed tax debt = $3,700.

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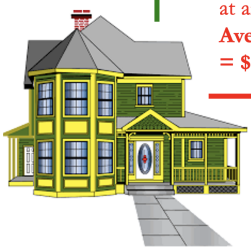

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Average final bid = $17,400.

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Interest (**1.5% monthly**) + one-time penalty (**10%**) accrues.

Interest and penalties stop accruing once redeemed by taxpayer or by title transfer.

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  - Look at non-repeat delinquency, arms-length, non-REO title transfers
  - Scale market value of property by observed 11% arms-length tax foreclosure prob.
  - $\implies \mathbb{E}[V]/\text{bid} = 11\%$ prob. $\times$ (\$578,100/\$17,400) $\approx$ **3.5 times auction price!**
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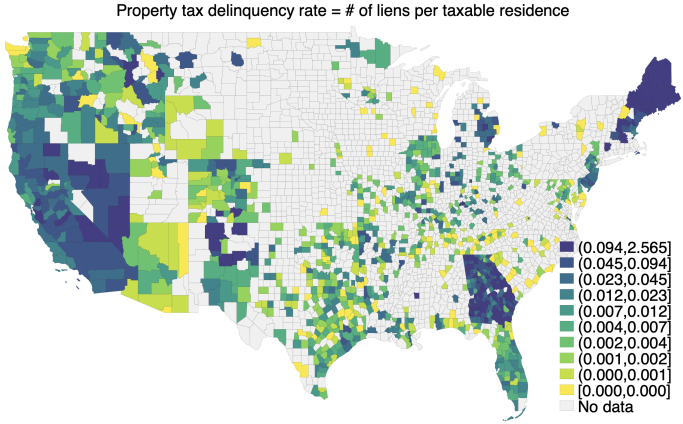
- **Underpricing** of tax foreclosure options **amplifies** property development relative to what might occur via mortgage foreclosures Option pricing

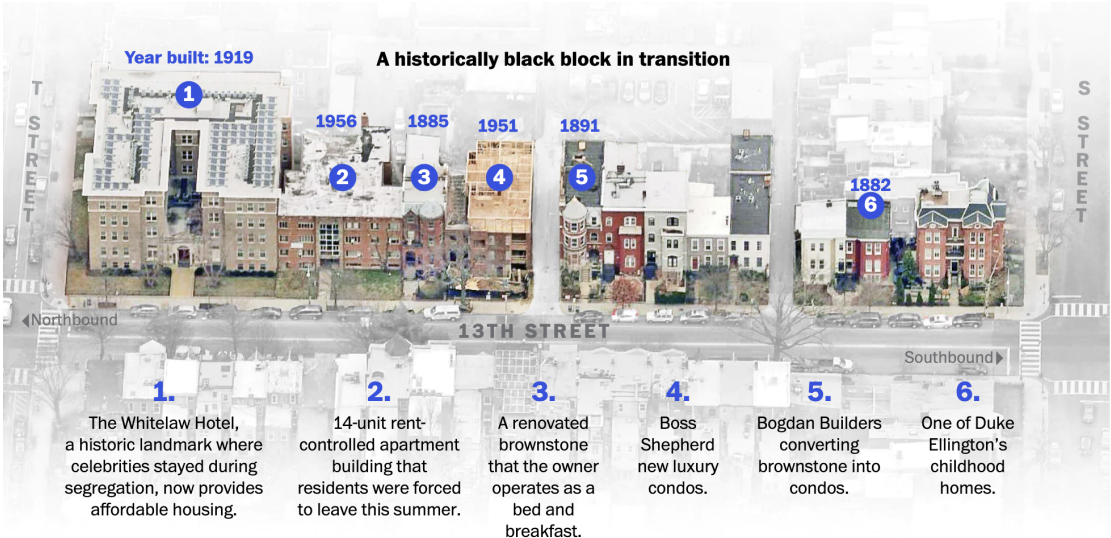
$\approx 2.2\%$ of taxable properties become delinquent each year



Notes: Tabulated using merged CoreLogic Involuntary Liens and Tax data for 2008 – 2014.

- Represents 2.3 million taxable residences each year Map w/state FEs
- Some states have much higher rates due to "revolving" liens (e.g. FL, GA)

Motivation: concerns about affordability within booming markets



Source: *Washington Post*, "Pushed out," September 21, 2019. Figure shows how two blocks on 13th St. NW in Washington, D.C. became steadily redeveloped over the last twenty years.

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     - ⋆ On average, values of neighboring homes 2-3% ↓ after tax sale
     - ⋆ Heterogeneity: due to redevelopment, in gentrifying areas prices 10% ↑ within 3 years

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4. **Document demographic changes resulting from tax sales**
   - ⋆ Gentrification: new homebuyers 2 p.p. less likely to be underrepresented minorities [URMs] after nearby tax sale to institutional investors (relative to baseline 12% URM buyer prob.)

New stylized facts about tax sale markets

- Little prior quantitative work on tax sales
  - Whitaker & Fitzpatrick (2013) on Chicago; Alm et al. (2016) on Cleveland
  - Large sociology literature on abandonment in Detroit (e.g. Akers & Seymour 2019)
- Property tax regressivity might contribute to delinquency outcomes
  - Hodge et al. (2017); Berry (2018, 2021); McMillen & Singh (2020); Amornsiripanitch (2023)

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- This paper: who is buying the tax claims, how, and why?
  1. Who? A small handful of investors acting as **intermediaries**
  2. How? Bidding for tax liens on properties **without a mortgage lien**
  3. Why? Relatively cheap redevelopment option in high CoL areas and high statutorily **guaranteed yield** on lien even without moving to foreclose

Other related work

- **Knock-on effects of distressed/affordable housing development**
  - Distressed sales: Campbell, Giglio, Pathak (2011); Anenberg & Kung (2014); Gerardi et al. (2015); Favara & Giannetti (2017); Gupta (2019); Ganduri & Maturana (2022)
  - Affordable housing: Autor, Palmer, Pathak (2014); Diamond & McQuade (2019), Asquith, Mast, Reed (2019); Boustan et al. (2019); Pennington (2021); Soltas (2022)
- **Corporate retail & "institutional" real estate investors**
  - Allen et al. (2018); Mills, Molloy, Zarutskie (2019); Bayer, Geissler, Mangum (2020); Bayer et al. (2021); Garriga, Gete, Tsouderou (2021); Buchak et al. (2021); Ganduri, Xiao, Xiao (2022); Gurun et al. (2022); Seiler & Yang (2022); Austin (2023); Billings & Soliman (2023)
- **Racial disparities in homeownership**
  - Brookings (2018); Kahn (2021); Kermani & Wong (2021); Bayer, Charles, Park (2021); Avenancio-León & Howard (2022); Zhang (2022); Gupta, Hansman, Mabille (2023)
- **Empirically identifying gentrification**
  - Brueckner & Rosenthal (2009); Guerrieri, Hartley, Hurst (2013); Glaeser, Kim, Luca (2018); Couture & Handbury (2019); Baum-Snow & Hartley (2020); Ding & Hwang (2020)

Other related work

- Knock-on effects of distressed/affordable housing development
- Corporate retail & "institutional" real estate investors
- Racial disparities in homeownership
- Empirically identifying gentrification patterns

Beyond new tax sale database, my contribution is to...

Establish links between distressed sales → intermediaries → developers, and how investors' strategies drive neighborhood change within municipal finance system.

Legal & Institutional Background

Property tax delinquency: basic principles

- By default, lien placed on property once a local tax obligation is delinquent
  - *In rem* instead of *in personam* taxation
  - $\Longrightarrow$ **debt follows property**, so cannot be discharged via bankruptcy
  - $\Longrightarrow$ not dominated by federal tax lien, so IRS has to buy out the lienholder
- Suppose property tax bill becomes overdue...
  - Household then begins to receive delinquency notices and penalties/interest accrue
  - Final notice to taxpayer usually sent 2-4 weeks before an annual tax sale event
  - If not paid by final due date, lien or deed sold to investors to recover revenue
  - Generally, same process for other local liens (e.g. sanitation or "weed" liens)

Systems | Auction map | Procedures | Portfolio | Bid types | Bid map

Example: Penultimate Notice with Bill Breakdown

Government of the District of Columbia
Office of the Chief Financial Officer
Office of Tax and Revenue

1101 4th Street, SW
Washington, D.C. 20024

Notice Number: 0712082190501

REAL PROPERTY TAX BILL

Square	Suffix	Lot	Property Address	Mrtg. No.	Assessment	Tax Rate/$100	Annual Tax
3310		0102	4306 3RD ST NW		$525,650	0.85	$4,468.02

DESCRIPTION	TAX	PENALTY	INTEREST	PAYMENT	TOTAL
2018	$4,309.16	$430.92	$711.01		$5,451.09
Total				**Payment due by May 31, 2019:**	**$5,451.09**

- In D.C., statutory 10% penalty rate + 18% annualized interest on the tax bill

Example: Final Notice Payment Stub for Delinquent Taxpayer

Payment: Payment to the "DC Treasurer" may be made online at www.taxpayerservicecenter.com or at any DC branch of Wells Fargo Bank or mailed (with payment coupon from below) to the Office of Tax and Revenue, Real Property Tax Administration, PO Box 98095, Washington DC 20090-8095 (please write your square, suffix and lot numbers on the check).

----------PLEASE DETACH HERE AND RETURN THIS PORTION WITH YOUR PAYMENT----------

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3310		0102	4306 3RD ST NW		$525,650	0.85	$4,468.02

Notice Number: 0731014190701

Notice Date: July 1, 2019

DCN # 1 9 1 2 0 7 6 5 5

Amount Enclosed: $, , .

For Official Use Only:

OFFICE OF TAX AND REVENUE
REAL PROPERTY TAX ADMINISTRATION
P.O. BOX 98095
WASHINGTON, DC 20090-8095

PAYMENT DUE BY:	**Jul 15, 2019**
AMOUNT DUE:	**$5,580.37**

7 3310 0102 191207655 0000558037

How is this related to mortgage foreclosures?

- Short answer: mortgage foreclosures & tax sales are (nearly) **disjoint** events
  - 0.9% of tax liens result in a mortgage foreclosure in merged CoreLogic/tax sale sample
  - Compared to 4.1% foreclosure rate for all CoreLogic title exchanges
- Banks w/capital stake in property would step in to redeem **super senior** tax debt
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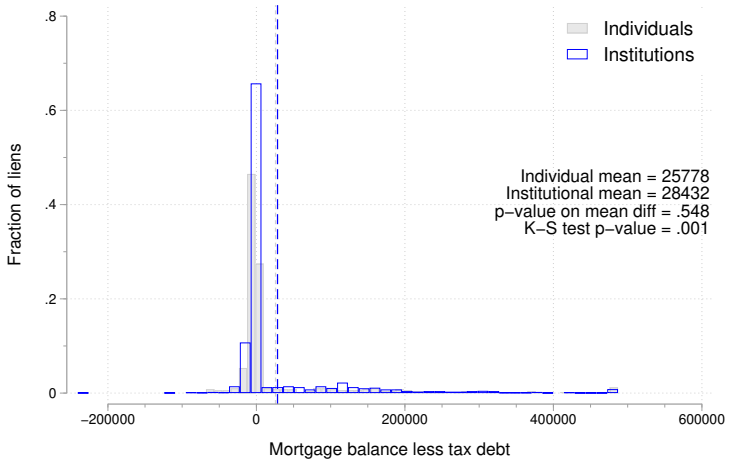
- **On the taxpayer side:** most lenders require **escrow** account with monthly payments used to cover local tax bill
  - HOs w/long tenure less likely to have escrow accounts, so payment not automatic
  - Potential elderly incapacitation channel (Moulton et al. 2022 *NTJ*) ADRD
  - Even within tract category, foreclosed properties further from elderly care sites
  - Result is price haircuts well below a mortgage foreclosure

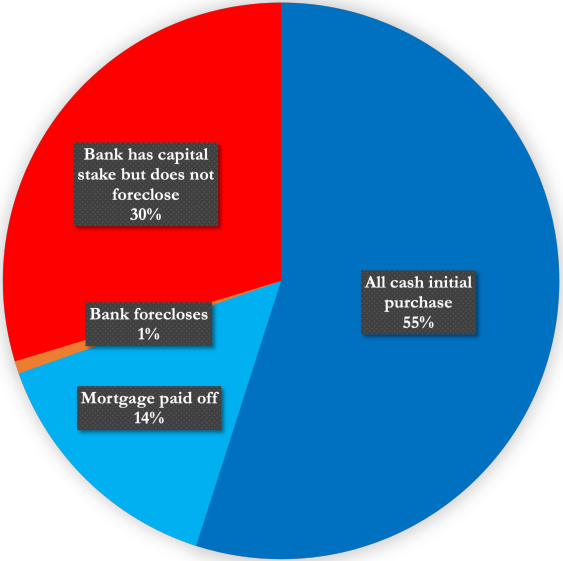
Most lenders have no money on table by auction date



- 54.8% of tax sale properties have no mortgage for last transaction prior to auction
- Of remaining 45.2%, 5.1 p.p. have a loan with term ending before the auction
- For remaining properties, use 30-year **amortization schedule**
- $\leq \$0$ or $\approx \$0 \implies$ not profitable for lender to redeem the tax lien

Amortization FRMs

Why wouldn't a lender step in to redeem debt?



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  - Also means more equity at stake if eventual foreclosure event
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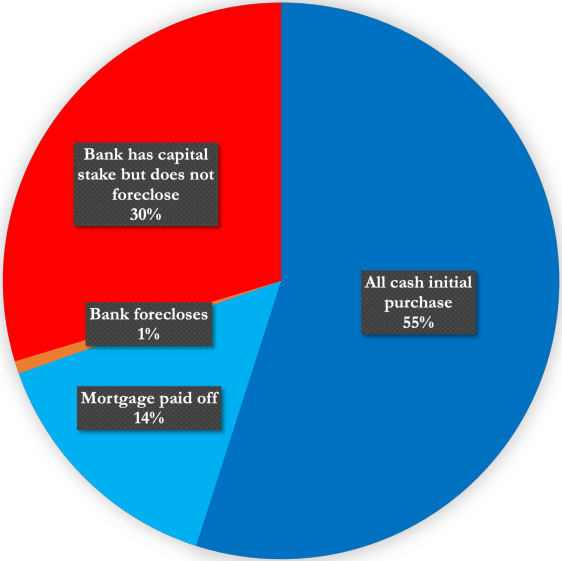

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- Why do some lenders have skin in the game but not foreclose?
  1. Homeowner (or other interested party) pays off their debt after the auction
  2. Lender pays off debt and then works with the homeowner to restructure their mortgage repayment schedule

Case Study: Washington, D.C. Tax Lien Market

Why is D.C. a good market to study?

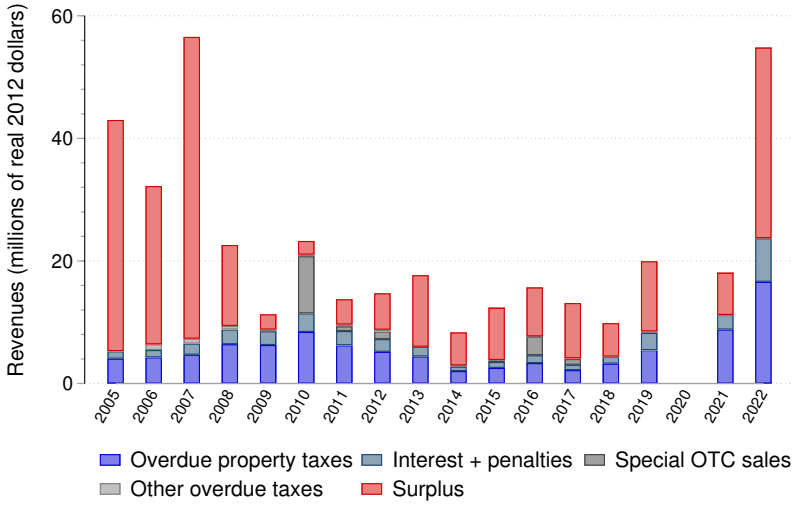
- Main reason: detailed auction records merged with CoreLogic and Zillow, but also...
  - Major RE market with high CoL Baltimore Indianapolis Detroit Ledger
    - ★ $240 bil. housing stock, or #11 ranked city globally (CBRE 2017)
  - City is heavily reliant on property tax revenues
    - ★ 32% of local tax revenues compared to 3% national average (FY 2019 Census ASSLGF)
  - Auction system follows majority of U.S. jurisdictions

- **In progress:** expand the analysis to all major metros w/records Details
  - Tax sales not systematically recorded in standard datasets ⟶ **create new database**
  - ZTRAX has auction flag, CoreLogic Involuntary Liens records just the lien event
  - Otherwise, rely on scraping, FOIA requests, geocoding tools ⟶ **300k liens collected**

Surplus from auction not given back to homeowner

Ledger

Surplus = bid amount − (back taxes + interest + penalties owed)



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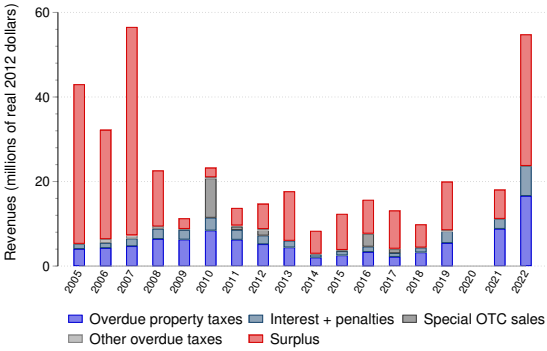

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- 2020 auction cancelled due to COVID

- Surplus is zero for OTC sales
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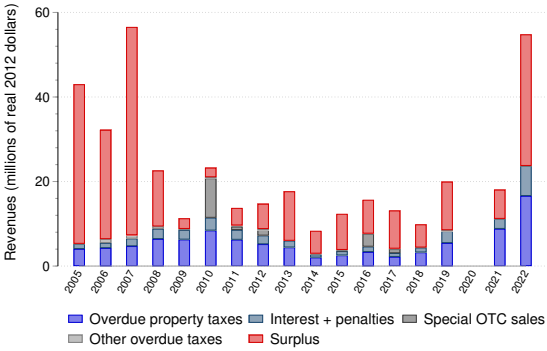

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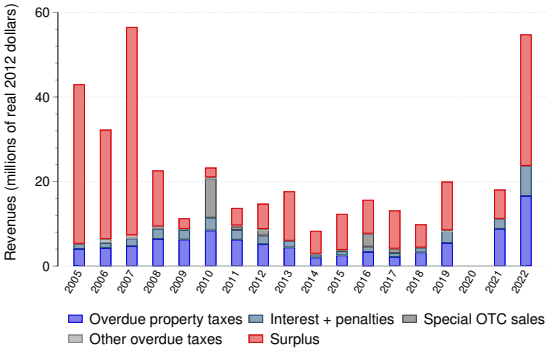

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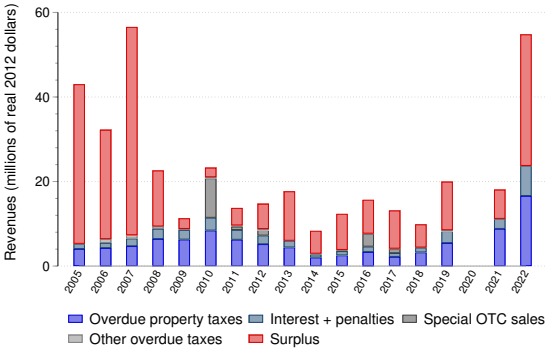

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- Gap between tax debt and subsequent sale prices is not rebated back to HO
- Subsequent foreclosure results in **home equity forfeiture**

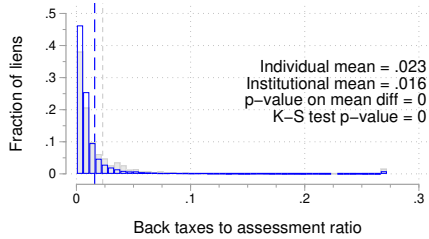
Bidding strategies vary by investor type

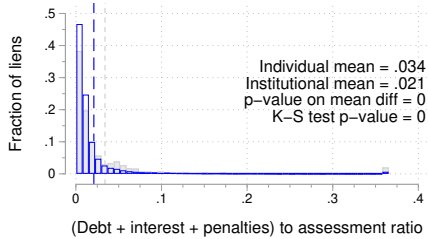
- Classify auction bidders into three types using keyword strings:
  1. **Investors:** e.g. "LLC", "FUND", "INC", "BANK", "REALTY", "PARTNERS", "CAPITAL", "TRUST", "CORPORATION", "PLLC" (Lambie-Hanson, Li, Slonkosky 2022)
  2. **Non-profits:** e.g. "PRAYER", "CHURCH", "COMMUNITY", "FAITH", "UNIVERSITY", "COLLEGE", "SCHOOL", "BAPTIST", "FOUNDATION", "GOVERNMENT", "EMBASSY", "CENTER", "COOPERATIVE", "FRIENDSHIP", "MINISTRIES", "FEDERAL", "REHABILITATION"
  3. **Individuals:** lienholders with (first name, surname) format + not containing keywords in above two lists

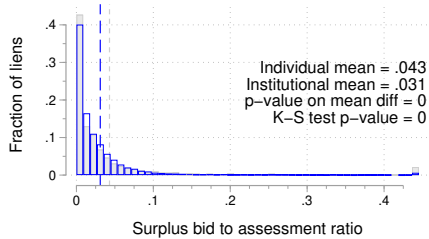
- In D.C. tax lien auctions, retail/institutional investors...
  - Purchase liens on more valuable properties in gentrifying areas Maps Distribution
  - Obtain higher **"foreclosure yields"** (lower bid-to-value) Distribution
  - Are more likely to bid in contested auctions Price index

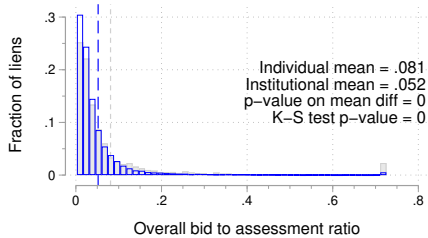
Bid-to-value ("foreclosure yield") by investor type

VTB YTM





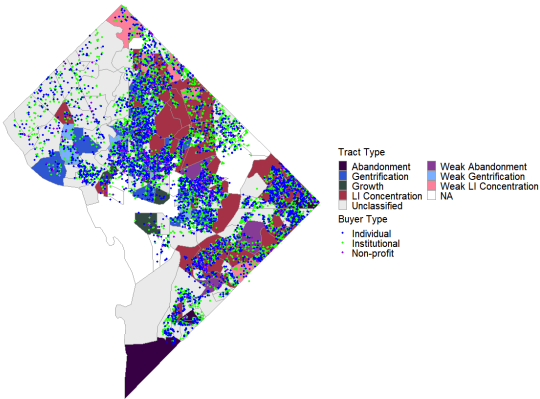




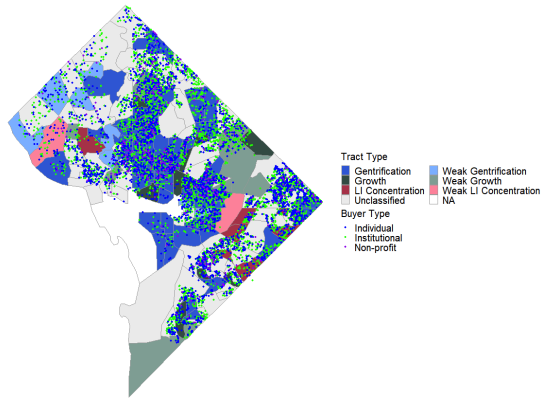
Individuals Institutions

Investors more likely to buy in gentrifying D.C. areas

A. Using 1990-2005 tract definitions



B. Using 2005-2019 tract definitions



- Excluding sales to non-profit buyers, 72% of all sales within initially gentrifying tracts were to institutional investors (57% before Lehman crash)

Crosstabs Intro Definition

Tax sale investors act as intermediaries to preserve corporate veil

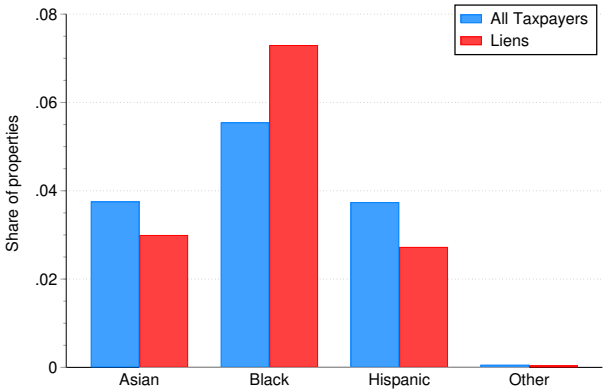
- **Who ultimately owns properties sold at tax auction?**
- Several challenges in answering this question:
  - Acquiring properties through tax foreclosure generates social opprobrium
  - Bidders need only provide an SSN/EIN, name, and address to bid
  - Strategic tax defaults to preserve anonymity: "repeat delinquency" events involving quick transfers between shell LLCs which appear in sample only once
- **Some defaulted properties can be linked to subsequent private equity deals**
  - Merge set of currently held properties to single-asset RE deals in Preqin $\longrightarrow$ 696 deals spanning 493 unique addresses in D.C., 2000-19
  - Hand-match to auction roster $\longrightarrow$ 19 residential + 24 mixed-use properties (59 deals)
  - Total PE deal value involving tax sale assets $>$ \$5 billion (matched sample)

PERE BINGO: BUYERS AND SELLERS IN POST-TAX SALE ASSET DEALS

- 26 of the 59 matched deals originate from "unidentified seller(s)," but some big names
- Intermediaries who buy at auction instead have amorphous names like HEARTWOOD 20 LLC, CAPITOL TAX SERVICES LLC, TIDEWATER ASSETS LLC, etc.

Deals

Clear racial disparities in incidence of tax delinquency



- Severe delinquency 2 p.p. more likely among Black homeowners (HOs) $\Longrightarrow$ 33% higher incidence than overall Black share of HOs
- Hispanics 27%, Asians 20% less likely to be delinquent than their HO share
- Method: Bayes's rule with Census common surnames list and voter registration Details Robustness
- **Disparate impact** from regressive assessments (Avenancio-León & Howard 2022)

Local spillover effects of tax liens on house prices

Key empirical challenges in this context

- Location of tax sales is endogenous to outcomes of interest
  - Owners more likely to become delinquent in struggling neighborhoods
  - Investors more likely to purchase in areas with higher expected returns
- Typical solution: control for **"very local"** time trends
- The timing of tax sales is also endogenous to counterparty decisions
  - Depends on whether tax authority can find a buyer (special OTC sales)
  - Owners may "strategically default" when redemption cost is low (O'Flaherty 1990)
- Possible solution on timing side: in national cross-section use differential pass-through of shocks to municipal budgets (reforms uncommon)
  - Weak second stage: state govt. redistributes across munis

Methods for isolating tax sale spillovers

- Compare several existing approaches in the literature:
  1. Ring DiD: compare outcomes in inner ring to those in outer ring around sale event M1
  2. Foreclosure wave regressions à la Campbell, Giglio, Pathak (2011) M2 Bulk buying
  3. **Empirical derivatives estimator** (Diamond & McQuade 2019): semi-parametric ring DiD by tracing out slope of conditional mean w.r.t. distance M3

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  - Overlapping rings here makes it tricky to define distance running variable

- **Alternative solutions:** define control group using something other than distance
  - Identify delinquent properties which were redeemed right before auction
  - ML methods to identify counterfactual tax lien sale locations (Pollmann 2021)

Standard method: foreclosure wave regressions

- Parametric version of ring analysis via POLS where include geography $\times$ time FEs, controls $\mathbf{X_{i,t}}$ for property characteristics:

$$\log(p_{i,c,t}) = \alpha_{c,t} + \gamma_m + \beta' \cdot \mathbf{X_{i,t}} + \delta_{C,B} \cdot g(N_{C,B}; D_{C,B}) \tag{1}$$
$$+ \delta_{C,A} \cdot g(N_{C,A}; D_{C,A}) + \delta_{F,B} \cdot h(N_{F,B}) + \delta_{F,A} \cdot h(N_{F,A}) + \varepsilon_{i,c,t}$$

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  - $g(\cdot)$: distance-weighted sum of tax sales where the weight is $\omega = \frac{0.1 - D(i)}{0.1}$
  - $h(\cdot)$: unweighted sum of tax sales
  - $\{B, A\}$ subscripts indicate before (B) vs. after (A) tax sale event
  - $\{C, F\}$ subscripts indicate whether i is "close" ($r < 0.1$ mi.) or "far" ($r < 0.25$ mi.)

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- Key estimate of interest: $\widehat{\delta}_{C,B} - \widehat{\delta}_{C,A}$ captures how one additional tax sale transfer influences values of nearby properties

	(1)	(2)	(3)	(4)
$\delta_{C,B} - \delta_{C,A}$	-0.033^{***}	-0.032^{***}	-0.028^{***}	-0.022^{***}
	(0.010)	(0.009)	(0.006)	(0.005)
$\delta_{F,B} - \delta_{F,A}$	-0.005^{**}	-0.005^{**}	-0.002^{**}	-0.002^{**}
	(0.002)	(0.002)	(0.001)	(0.001)
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Multi-family dummy		✓	✓	✓
Property controls			✓	✓
Winsorized				✓
N	100,504	100,504	66,461	66,461
Adj. R^2	0.427	0.452	0.708	0.771

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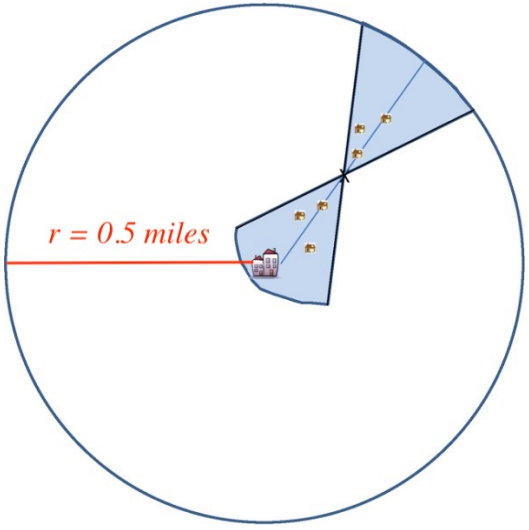
- Tax sales more common and geographically clustered than mtg. foreclosures or bankruptcy Mortgage table
  - 99.9th percentile to the maximum is 64.12–94.11 tax sales
- Can $\approx$ match $(\widehat{\delta}_{C,B} - \widehat{\delta}_{C,A})$ in mtg. foreclosure literature if I use exact same set of controls/sampling

Method #3 (illustration): the "bowtie" in the ED method



- Idea: account for very local time trends by tracing out how outcomes **continuously** evolve w.r.t. time/distance to event
  - Compare property pairs $\pm\delta$ away in Polar coordinate plane for fixed θ

Title changes | Details | Calibration | Full tables | Robustness

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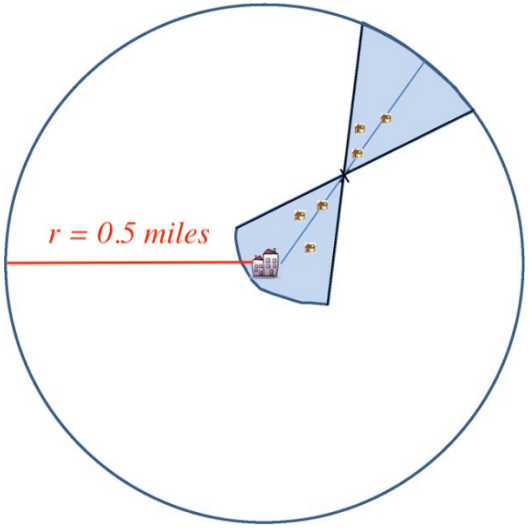

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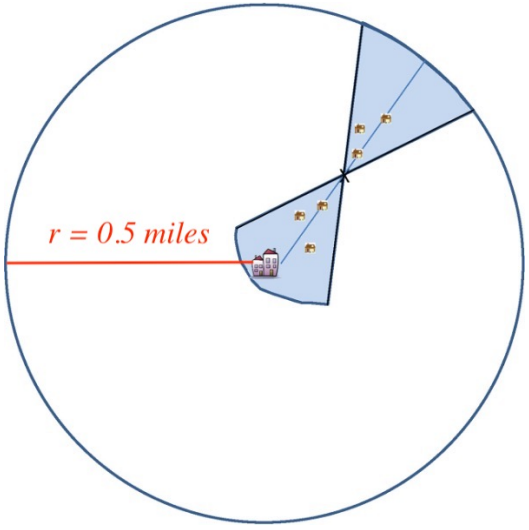

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- **Semi-parametric:** pick ring radius and "smoothing" parameters to determine size of shaded area

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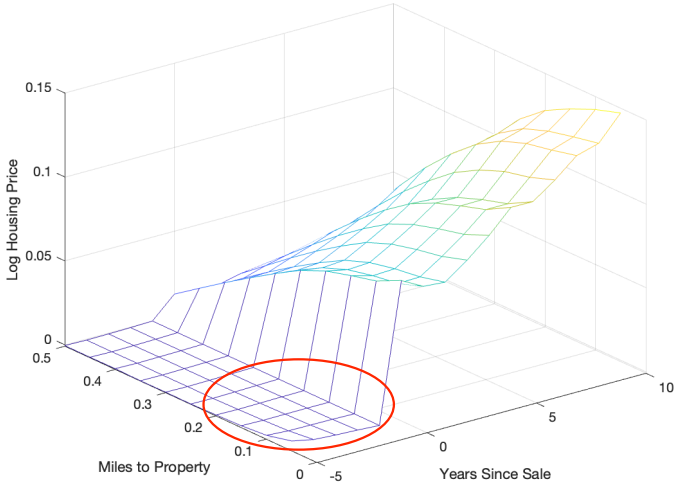
$\Delta P >> 0$ in up-and-coming areas after tax sales to investors

Sales in recently gentrifying tracts



- Focus on arms-length transfers to investors after tax auction

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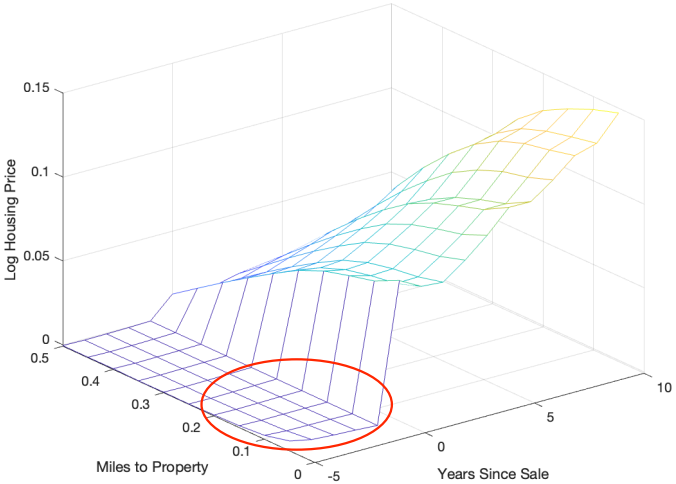

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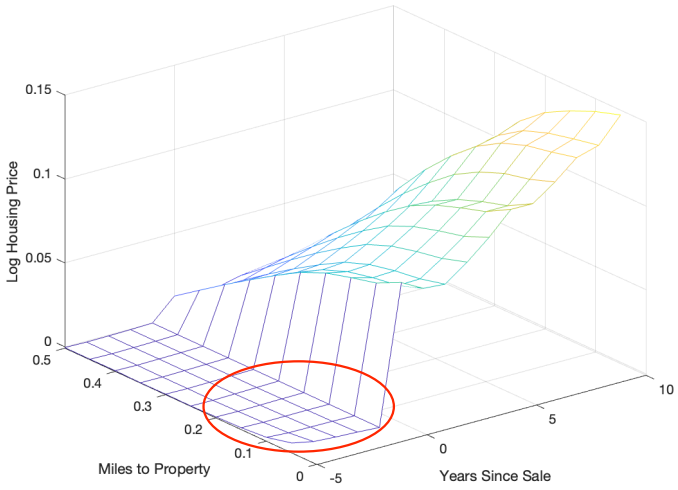

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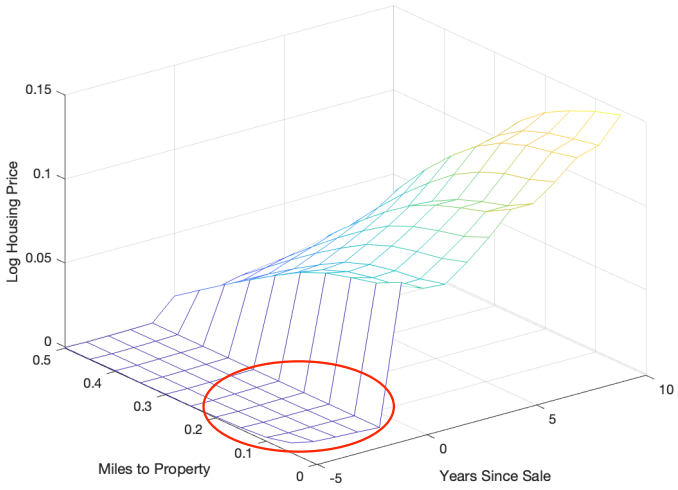

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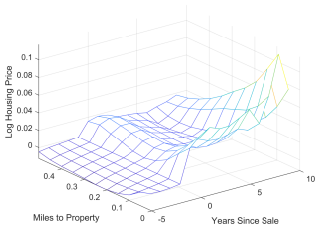
- Similar effects whether define event as foreclosure sale to LLC vs. non-LLC investor Individuals

Heterogeneous effects by neighborhood type

A. Sales in previously gentrifying tracts



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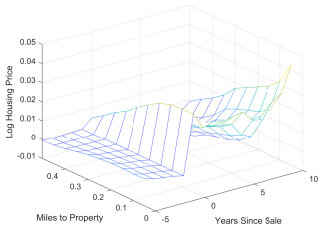
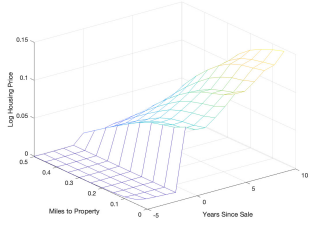


C. Sales in recently gentrifying tracts



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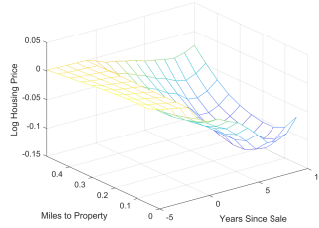

- Price 7%↓, decaying with distance in non-gentrifying areas

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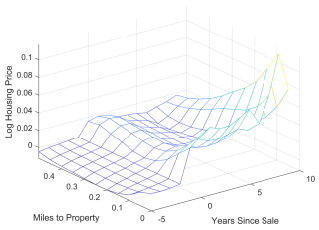

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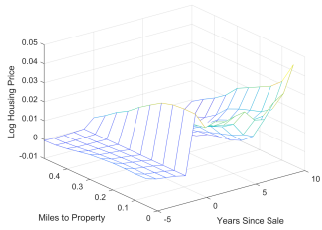

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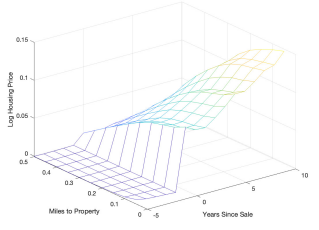

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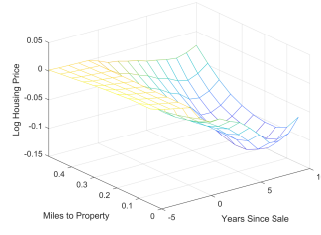

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  - *ex ante*: 1990 – 2005
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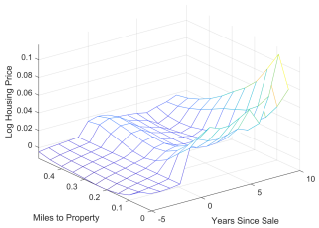

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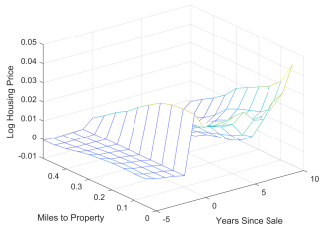

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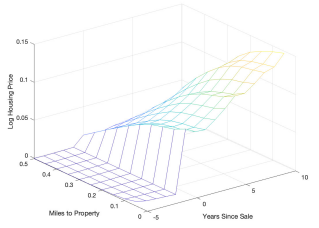

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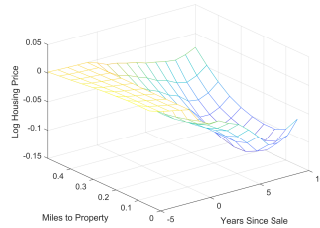

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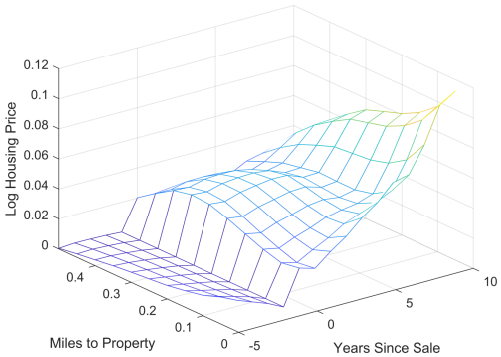
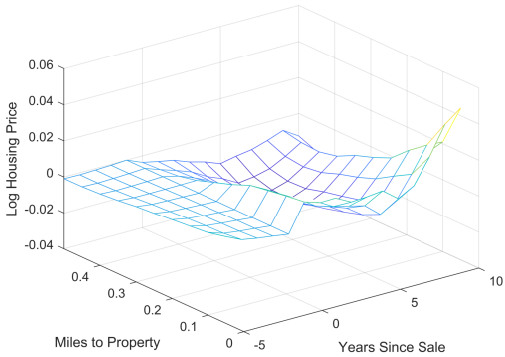
- Tax sale investors act as **opportunistic developers**

Evidence in favor of blight reduction channel

A. Most foreclosures (top quartile)



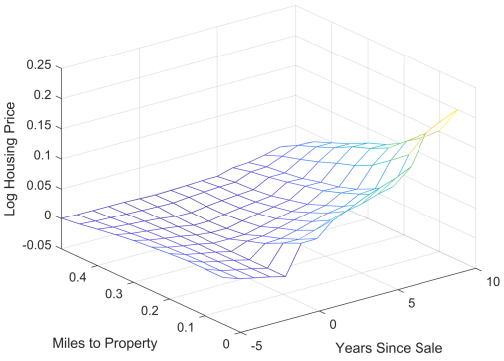
B. Least foreclosures (below median)



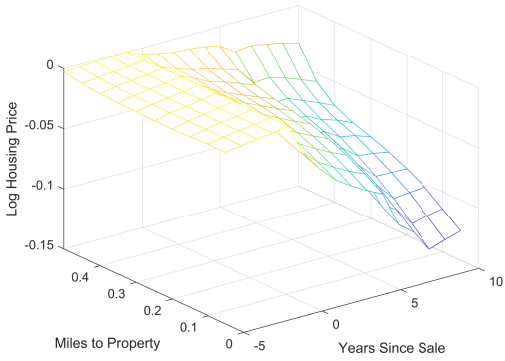
- Consistent with the (+) effects of non-profit rehabs in Ganduri & Maturana (2022)
- Holds even if exclude tax sales involving properties w/mortgage lien

Evidence also goes against strong supply channel

A. Thinnest markets



B. Thickest markets



- Tax sales might improve very local housing supply by inc. inventory $\implies P \downarrow$
- Here demand effects (blight reduction + amenities + sorting) dominate supply effects

Neighborhood demographic changes through tax sales

Do tax sales drive local demographic change?

- Two ("push-pull") forces through which this might happen in SFH market:
  - **Gentrification:** pos. pricing externalities $\implies$ neighborhood becomes more inaccessible to lower-income, non-white residents (URM buyer share $\downarrow$)

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- Evidence here consistent with gentrification channel Bayes's rule Specification
  - URM buyer prob. declines by 2 p.p. (relative to a 12% baseline prob.)
  - But URM seller prob. also declines by 3 p.p. (relative to a 10% baseline prob.)
  - No consistent patterns around tax sales to individual investors

ED-style method w/race probability outcome

- ED method does not converge for areas which are highly segregated (corner solutions)

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$$URM_{i,r,t} = \sum_{k=-3}^{+5} \left\{ \sum_{d=0.05 \text{ mi}}^{0.5 \text{ mi}} \beta_{d,k}^{close,a} \cdot TaxSale\_Close_{i,t,d,k}^{a} \right. \tag{2}$$

$$\left. + \sum_{d=0.5 \text{ mi}}^{1 \text{ mi}} \beta_{d,k}^{far,a} \cdot TaxSale\_Far_{i,t,d,k}^{a} \right\} + \alpha_{r,t} + \gamma_{m} + \eta' \cdot \mathbf{X_{i,t}} + \nu_{i,r,t}$$

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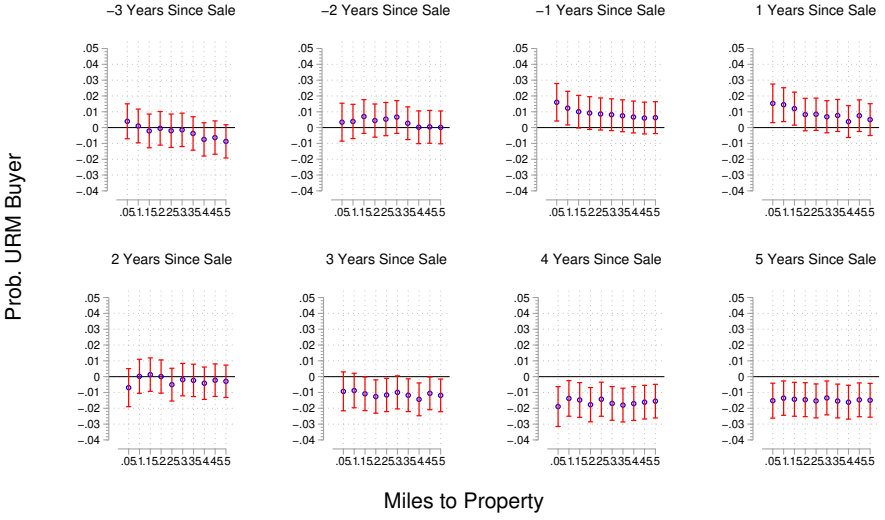
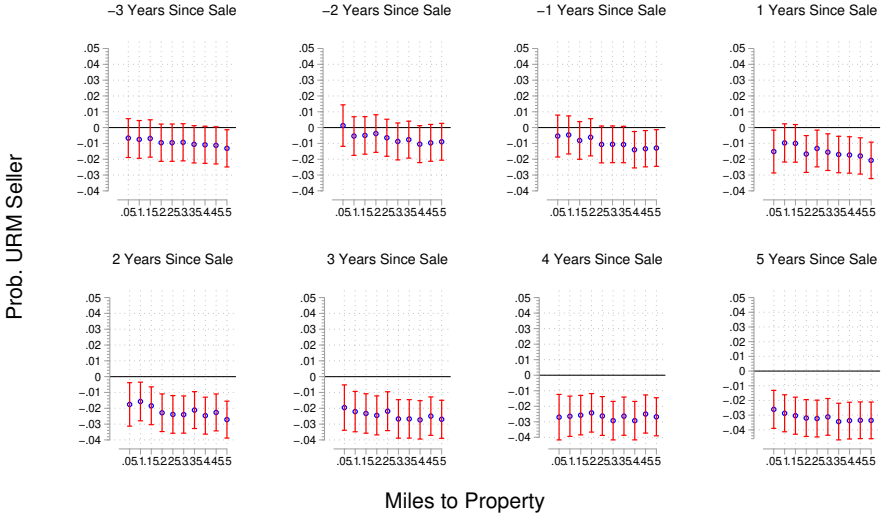
  - e.g. $TaxSale\_Close_{i,2005,0.1,-1}^{a} = 1$ if house i purchased within 0.1 mi. of tax sale property w/title change to investor of type a in 2006
  - $\alpha_{r,t}$: ring, block group, or 9-digit zip code $\times$ year FEs
  - Controls $\mathbf{X_{i,t}}$: lat/lon, # bed/baths, floor space, lot size, house age quadratic

2% ↓ in URM buyer prob. after tax sale foreclosure



URM seller prob. ↓ ⟹ more white-to-white sales



Policy Implications

Recently concluded legal battle over "home equity theft"

States Are Not Entitled to Windfalls in Tax Disputes, Supreme Court Rules

In a unanimous decision, the justices sided with a 94-year-old woman who got nothing when a Minnesota county sold her condominium to recoup unpaid taxes.

Give this article

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Source: *NY Times* (May 25, 2023).

- *Tyler v. Hennepin County*: 94 year-old Minnesota widow who had $40k home seized to pay off $15k in local tax debts
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- Big implications for property tax reform
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- Ongoing issues over **"disparate impact"**

What does this paper have to say about property tax reform?

1. Valuation of excess proceeds: use *ex ante* prices to the extent that auction process undervalues properties and *ex post* properties may amplify inequality
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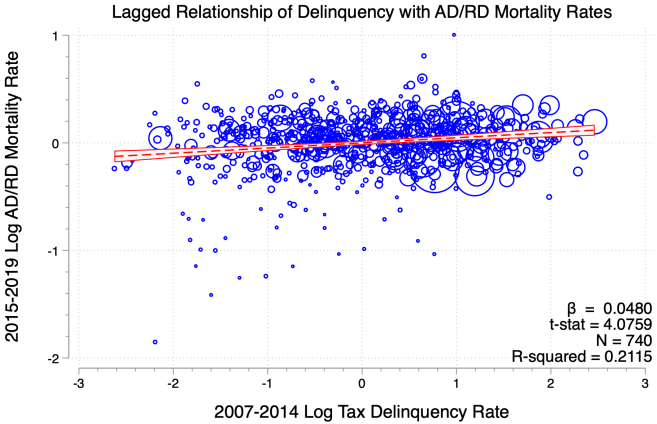
3. Priority liens: remove super seniority of tax liens in certain situations
4. Mental health interventions:
   - Payments column in ledgers empty in % of cases $\implies$ not just a liquidity story
   - **Incidence of Alzheimer's/related dementia (AD/RD) cases plays a role**
5. **Financial innovations:** create escrow-mimicking account with opt-in provision that automatically pays taxes, even if no mortgage loan attached
   - Functions like payroll tax withholding and helps solve delinquency problem

Using delinquency to detect early memory impairment

Go back



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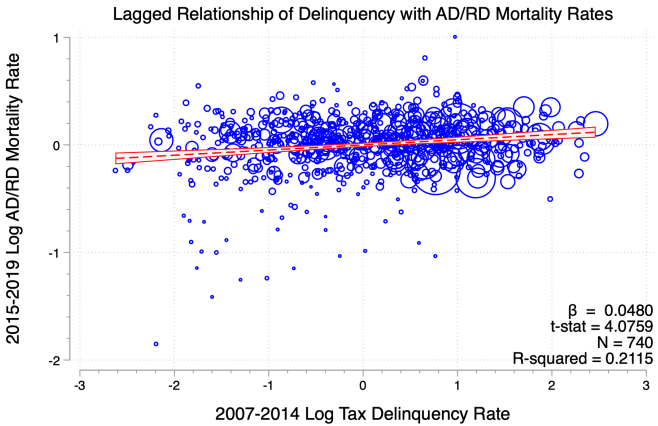
Using delinquency to detect early memory impairment

Go back



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- Placebo: not true if look at death rates from acute causes (e.g. heart attacks)

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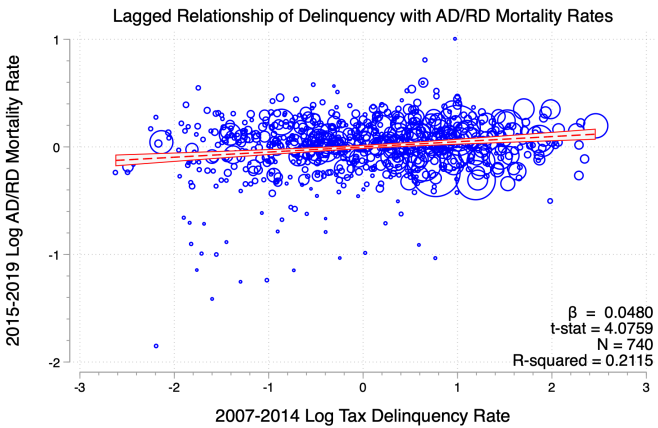

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- Strong (+) association of delinquency with future deaths from Alzheimer's Disease & dementias (AD/RD)
- Placebo: not true if look at death rates from acute causes (e.g. heart attacks)
- Missing payments as an indicator of **memory impairment**
- Nationwide database of mortality records linked to CoreLogic
- Precision public health initiatives using publicly available data

Conclusion

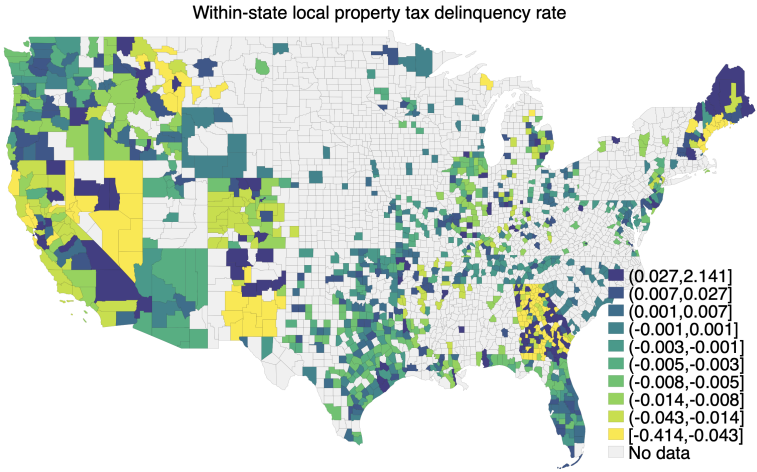
- Municipalities hold **tax sales** to recoup lost revenue
  - Buyer composition strongly tilted towards institutional investors around 2008
  - **Non-REO intermediaries** target high-value properties in gentrifying areas
- Local price spillover effects: $(-)$ on average, but **$(+)$ in gentrifying areas**
  - Investors accelerate demographic trends by redeveloping delinquent properties
  - Blight reduction: stronger $(+)$ effects in areas with more foreclosures
  - Tax sales amplify within-city racial inequality by crowding out URM buyers
- **Finance-based microfoundation** for gentrification waves within cities
- **Policy: rebate surplus revenues** to delinquent taxpayer instead of the foreclosing entity while (barely) hurting investors' profits $\longrightarrow$ use ex ante price basis

THANK YOU!

Appendix

Spatial distribution of property tax lien delinquency rates

Go back



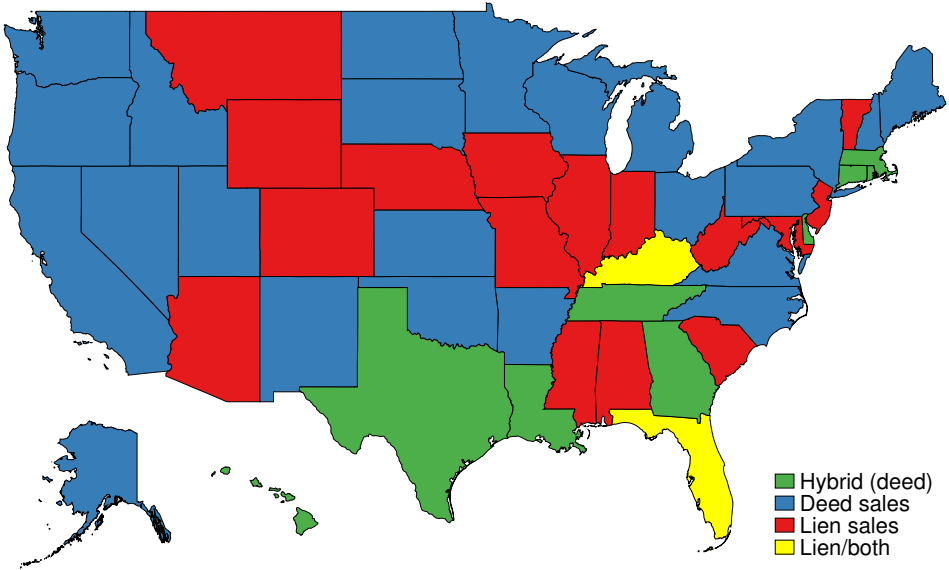
Notes: Tabulated using merged CoreLogic Involuntary Liens and Tax data for 2008 – 2014.

- Residualize on state FEs to hold fixed property tax legal regime

Classifying tax lien systems

Main deck

- Jurisdictions divided into three types based on how they sell claims:
  1. Lien sales: interest-bearing certificate with foreclosure option sold at auction or OTC
  2. Deed sales: local authority – tax or sheriff's office – directly forecloses and then sells deed at auction or OTC ("special sale")
  3. Hybrid sales: like a deed sale, except redemption period needs to pass before investor can convert deed to title
- No clear political divide in how jurisdictions arbitrate delinquency
- Since redemption periods in deed states can be long, **not much economic distinction between a lien sale and deed sale system**
  - Difficult for homeowner to redeem in hybrid states because need to pay back both outstanding tax debt + penalties/fees + $\underbrace{\text{whatever premium the investor bid}}_{\text{"credit bid"}}$


Hybrid (deed)
Deed sales
Lien sales
Lien/both

Some common tax sale procedures across states...

Main deck

1. Local authority sets auction date and lists properties on website for investors to review
   - This usually happens when the final notice is sent to the taxpayer $\implies$ properties redeemed at last minute as potential control group
   - Govt. might also allocate funds to advertise the tax sale
2. Almost all tax sales held in person – cancelled in 2020-21 due to COVID
   - Online sales conducted as sealed price auctions with very little time between lots
3. Bidders register with an SSN or EIN for W-9 filing and ownership record
   - Corporate veil: easy to preserve anonymity, since can create a shell or hire an intern
4. Investors place security deposit + fees with clerk prior to placing bids

Types of tax auctions

Main deck

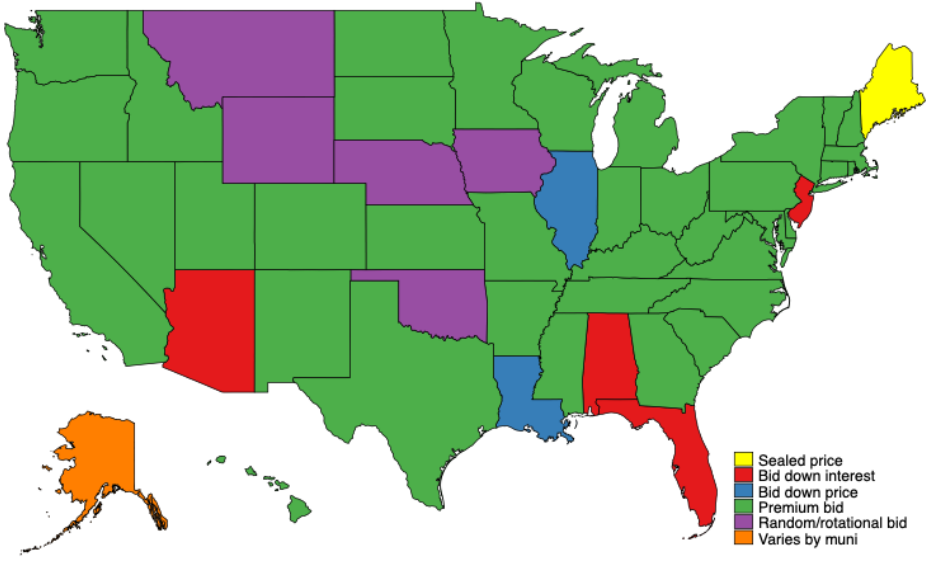
There are five types of tax auctions, with some limited within-state variation in rules...

1. Premium bid: investors bid a premium relative to the outstanding tax bill
2. Bid down interest: Dutch auction where buyers pay off the tax debt and bid minimum interest they are willing to accept
3. Random/rotational bid: tax authority sets "buy it now" price for each property and bidder numbers randomly called for each lot until someone buys
4. Bid down price: same as bid down interest (IL and LA)
5. Sealed first price (Vickrey): currently only in Maine

- Premium bid by far most common method used by 39 out of 51 states
- Starting bid typically set so the tax authority breaks even

Bidding methods by state

Main deck



Valuing tax liens as a financial asset (Part #1)

Go back

- Extend hybrid option models of Stanton (1995) and Jarrow & Tyagi (2007)
- NPV of a tax lien given foreclosure date χ is then the expected value from the coupons + the property's liquidation value in foreclosure less the bid

$$NPV_0(\chi) = \mathbb{E}_Q\Bigg(\underbrace{\mathbb{1}\{0 \leq \tau \leq \chi\} \cdot C \cdot \exp\Big(\lambda \cdot \max\{r, i, \tau\} \times \mathbb{1}_A\Big) \times \exp\Big(-\int_0^\tau rds\Big)}_{\text{interest coupons to lienholder}}$$

$$+ \underbrace{\Bigg(\mathbb{1}\{T^* \leq \chi \leq \tau\}\Big[\min\{P_\chi, C \cdot \exp\Big(\lambda \cdot \max\Big\{r, i, \chi\} \times \mathbb{1}_A\Big)\Big\} - K\Big]\Bigg) \times \exp\Big(-\int_0^\chi rds\Big)}_{\text{liquidation value in foreclosure}} \Bigg) - \underbrace{C - S}_{\text{total bid}}$$

- Foreclosure date χ, where option vests once redemption period of length T^* passes
- C is the tax debt, S is surplus, where total bid is $C + S$

Valuing tax liens as a financial asset (Part #2)

Go back

$$NPV_0(\chi) = \mathbb{E}_Q\Bigg(\underbrace{\mathbb{1}\{0 \le \tau \le \chi\} \cdot C \cdot \exp\Big(\lambda \cdot \max\{r, i, \tau\} \times \mathbb{1}_A\Big) \times \exp\Big(-\int_0^\tau r ds\Big)}_{\text{interest coupons to lienholder}}$$

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- $A = (i \neq 0)$ and indicator $\mathbb{1}_A$ indicator function for set A
- Delinquent HO picks intensity λ by deciding on redemption time
- Minimum interest rate embedded in tax lien if not redeemed $= r \times \mathbb{1}_A$
- Exercise foreclosure option whenever $P_\chi > C + S + K$
  - K is opportunity cost from the PV of (legal) costs incurred over the foreclosure process as of χ

Example: returns on a multi-state tax lien portfolio

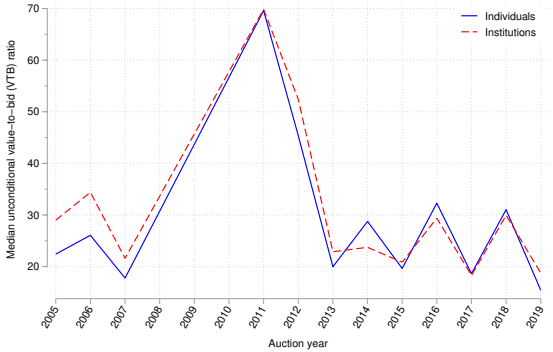
Main deck

	Washington, D.C.	Florida	Massachusetts
Sale method	Lien	Lien	Hybrid
Bid method	Premium bid	Bid down interest	Premium bid
Redemption period	6 months	2 years	6 months
Maturity/expiration	6 months	7 years	6 months
One-time penalty rate	0%	5% minimum	0%
Annual interest rate	12%	18%	16%
Assumed total bid value	\$16,000	\$1,000	\$100,000
Assumed premium bid	\$2,000	N/A	\$75,000

- Suppose investor holds each lien until redemption period ends
- Without exercising foreclosure option, guaranteed yields to maturity would be 5.1% on D.C., 18% on FL, and 7.7% on MA lien
  - Ex: for D.C., $(\$16\text{k} - \$2\text{k}) \times [(1 + 0.0095)^6 - 1]/\$16\text{k} = \$816.21/\$16\text{k} = 5.1\%$

Value-to-bid ratio spiked around GFC

Go back

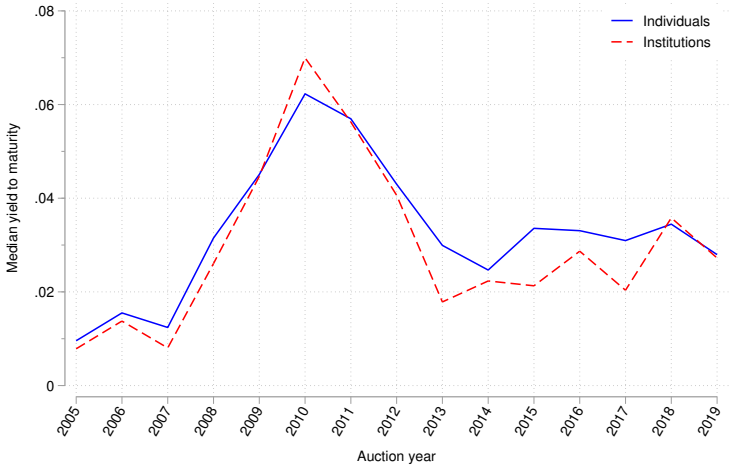


- Unconditional value-to-bid (VTB) without adjusting for redemption or collateral risk
  - Similar discrete spike if adjust for both
  - Court foreclosure prob. ↓, but quiet foreclosure prob. ↑ over time
- Not solely driven by mortgage foreclosures where bank let the property go
  - Exclude special OTC auctions
- Even with covariate-adjustment, no decline in VTB over time
- Suggests information asymmetry (Zillow) not driving spreads

Yield-to-maturity also spiked around GFC

Go back

$$\text{YTM} = (\text{bid} - \text{surplus}) \times (1 + r)^n / \text{bid}$$



Average annualized YTM for holding liens is $\approx$ 4%-5%

Go back

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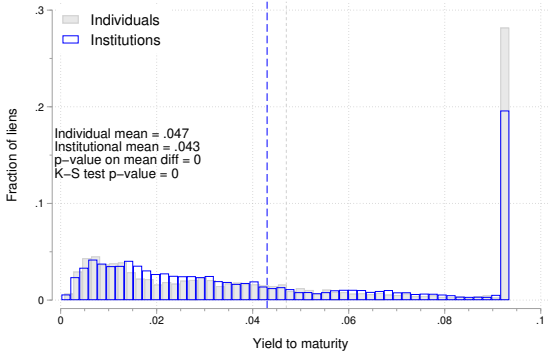


- Monthly interest rate r high across all lien states (10% – 20% p.a.)
- Redemption period n varies from 6 months (MD/D.C.) to 48 months (WY)
- Example: in D.C., YTM maxes out at $(1 + 0.015)^6 = 9.34\%$
- YTM higher for individual investors
  - Less likely to compete in contested auctions or file for foreclosure
  - If condition on surplus > 0, institutions earn 10 bps. higher YTM

Algorithm for determining mortgage lien status

Main deck

- **Basic idea:** match tax sale properties to loan contracts repoted in CoreLogic...
  - For D.C. sample, match on address/square combo

1. Determine main contract features: FRM vs. ARM, origination amount C_0, quoted rate i, term N, payment frequency, etc.
2. Drop properties matched to a refinancing or second mortgage event
3. For FRMs, use standard accounting formulas (see next slide) to obtain C_n balance, where n is # months into the loan when tax sale occurs
4. For ARMs ($<$ 10% of loans), assume standard contract features consistent with HMDA/FHFA MIRS (e.g. 5/1 loan with 1-year T-bill index)
5. For remaining loans with i but missing term and contract type, assume 30-year FRM $\implies$ overestimate balance C_n

- Loan fully with quoted rate i amortizes over N months, so expand the geometric series to obtain monthly payment (PMT)

- Then iterate on the initial law of motion $C_1 = (1 + i/12) \times C_0 - PMT$ to find balance after n months of payments

$$C_0 = \sum_{t=1}^{N} \frac{PMT}{(1 + i/12)^t} \implies PMT = C_0 \times \left(\frac{i/12}{1 - (1/(1 + i/12))^N} \right)$$

$$C_n = (1 + i/12)^n \times C_0 - \sum_{t=0}^{n-1} (1 + i/12)^t \times PMT$$

$$\implies C_n = (1 + i/12)^n \times C_0 - \frac{PMT \cdot \left((1 + i/12)^n - 1 \right)}{i/12}$$

Summary statistics: most auction revenues from surplus bids

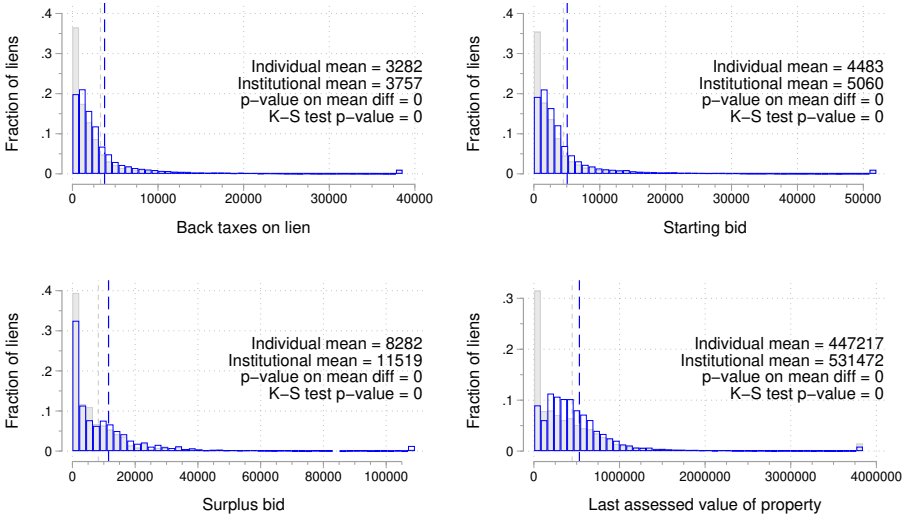
Main deck

Year	# liens sold	Back taxes	Interest/penalties	Surplus	Auction revenues	**Surplus-revenue ratio (%)**	Total tax revenues
2005	2,181	3.52	1.04	32.76	37.35	87.71%	1,136
2006	1,997	3.81	1.07	23.06	28.77	80.16%	1,212
2007	2,083	4.31	1.65	45.11	51.82	87.06%	1,542
2008	1,366	6.05	2.27	12.46	21.31	58.46%	1,727
2009	1,068	5.91	2.11	2.33	10.61	21.99%	1,839
2010*	1,622	8.06	2.90	2.13	22.27	9.56%	1,891
2011***	1,998	6.13	2.27	4.04	13.49	29.93%	1,734
2012*	1,248	5.17	2.06	5.93	14.72	40.32%	1,880
2013	965	4.48	1.61	11.82	17.91	66.00%	1,951
2014	316	2.08	0.74	5.53	8.57	64.56%	2,035
2015*	534	2.62	1.00	8.77	12.73	68.91%	2,267
2016**	1,040	3.47	1.33	8.32	16.32	50.94%	2,364
2017*	675	2.31	0.93	9.54	13.92	68.49%	2,579
2018	516	3.51	1.21	5.89	10.66	55.23%	2,591
2019	810	5.99	3.08	12.58	21.93	57.37%	2,807
Total	**18,419**	67.42	25.26	190.28	302.39	**62.92%**	29,556

Notes: All monetary values in millions of nominal dollars. Surplus-revenue ratio is surplus divided by auction revenues. The number of stars indicates the number of special OTC sales in that year. Tax auction variables sourced from the buyer's books for 2005 – 2019 available through the Washington, D.C. OTR.

Bid components (real 2012 $) by investor type

Main deck



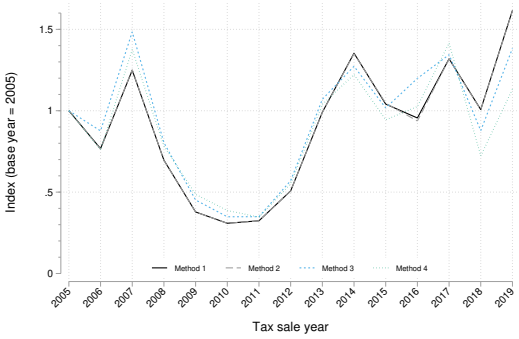
Main deck

Deal date	Buyer(s)	Seller(s)	Property name	Current use	Deal size	Square footage	Tax sale date	Auction price	Lien buyer(s)
1/2010	The Goldstar Group	Unidentified	The Floridian	Condominiums	N/A	N/A	12/2009	$4,472	CAPITAL SOURCE BANK FBO
2/2010	CBRE Investment Management	PGIM Real Estate	Mass Court†	Multi-family	$100.5 M	200,000	9/2008	$35,005	US BANK-CUST/SASS MUNI V DTR
4/2010	Somerset Development Co. THC Affordable Housing Unidentified buyer(s)	Unidentified	Webster Gardens Apartments	Multi-family	N/A	N/A	7/2006	$7,768	CAPITOL TAX SERVICES, LLC
7/2010	Cadila Healthcare Ltd.	Akridge	1016 16th St	Mixed-use	N/A	38,250	11/2009	$8,548	ETS DC LLC
3/2011	Wells Real Estate Funds	Beacon Capital Partners	Market Square	Mixed-use	$615 M	681,051	11/2009	$5,309	SALTA GROUP INC
6/2011	JCR Companies	Unidentified	301 Massachusetts Ave NW	Retail	N/A	4,000	9/2008	$11,986	REDEMPTOR LITIUM LLC
7/2011	Greystar Real Estate Partners	Lehrco	The Warwick†	Multi-family	$65.1 M	460,262	9/2010	$39,086	MUNITRUST CAPITAL FUND II LLC HEARTWOOD 20, LLC
8/2011	JCR Companies	Unidentified	1723 Connecticut Ave NW	Residential	N/A	N/A	7/2011	$52,144	US BANK CUST/EMP IV, CAP ONE
7/2012	Host Hotels & Resorts	Quadrangle Development Corporation	Grand Hyatt Washington	Hotel	$400 M	N/A	9/2010	$9,505	REDEMPTOR LITIUM LLC
6/2013	The Goldstar Group	Unidentified	425-427 8th St SE	Mixed-use	$1.7 M	3,155	7/2012	$23,880	REDEMPTOR LITIUM
9/2013	Rose Green Cities Fund	Unidentified	Portner Flats	Multi-family	N/A	40,860	7/2006	$15,596	HEARTWOOD 88, LLC
11/2013	Lone Star Funds	Wereldhave	1401 New York Ave NW	Office	$71 M	300,000	12/2010	$371,957	WCP DC23 HOLDINGS, LLC
11/2013	Urban Investment Partners Perseus TDC PRP	Unidentified	Capitol Park Tower	Multi-family	N/A	N/A	9/2008	$8,507	REDEMPTOR LITIUM LLC
12/2013	Hines	Lehman Brothers Real Estate Private Equity MacFarlane Partners Monument Realty	55 M St	Mixed-use	$141.9 M	266,566	7/2006	$8,661	AEON PROPERTIES, LLC
6/2014	Rezross Investment Group LLC	DeShah Capital	2209 Massachusetts Ave NW	Office	N/A	9,000	7/2012	$50,494	REO AMERICA INC CUST AS
7/2014	Jamestown	Vornado Realty Trust Angelo Gordon & Co.	Georgetown Park	Mixed-use	$319 M	315,028	9/2008	$15,036	AEON FINANCIAL IV, LLC - SERIES
12/2014	PRP	Unidentified	2501 Residences on Street	Condominiums	$31.6 M	100,000	9/2011	$4,873	RICHARD T. COCKERILL
6/2015	Mill Creek Residential	Potomac Construction Group The Garrett Cos. Valor Development	2700 16th St	Office	$16.2 M	35,000	7/2012	$160,842	ABBOTT DEVELOPMENT GROUP
10/2015	Blackstone Group	Columbia Property Trust	Market Square	Mixed-use	$291.6 M	686,000	7/2012	$5,542	ELM CAPITAL LLC
4/2016	JCR Companies	Unidentified	916 G St NW	Retail	$3.2 M	6,200	9/2008	$11,557	POTOMAC TAX SERVICES LLC
4/2016	KHP Capital Partners	Xenia Hotels & Resorts	The Darcy Hotel	Hotel	$65 M	N/A	12/2010	$56,435	WCP DC23 HOLDINGS, LLC
11/2016	NOVO Properties	Unidentified	1440 Chapin Street Apartments	Multi-family	$4.1 M	N/A	7/2007	$6,935	US BANK-CUST/SASS MUNI V DTR
4/2017	Pearlmark Real Estate Partners Lincoln Property Company	Unidentified	619 14th St NW	Office	$57 M	35,000	9/2008	$12,797	TCF NATIONAL BANK FBO AEON
6/2017	Jefferson Apartment Group Stars Investments	Bristol Capital Corporation Multi-family	2009 8th St NW	Multi-family	$25 M	25,050	7/2005	$50,597	HEARTWOOD 88, LLC
1/2018	Atalaya Capital Management Urban Investment Partners	JP Morgan Asset Management	Onyx on First	Multi-family	$95.5 M	N/A	7/2006	$17,084	MUNITAX FUND, LLC
3/2018	TA Realty	JP Morgan Asset Management	Gables Woodley Park	Multi-family	$106.5 M	N/A	7/2016	$23,282	DUPONT TAX SERVICES, LLC
8/2018	Marx Realty	Unidentified	819 7th St NW†	Mixed-use	$11.6 M	21,952	7/2016	$229,421	SUNSHINE STATE CERTIFICATES NEBRASKA ALLIANCE REALTY
8/2018	Artemis Real Estate Partners Jair Lynch	Level 2 Development FCP	Takoma Central	Multi-family	$50.6 M	82,935	7/2007	$27,676	FEDOR TOMENKO
10/2018	Aria Investment Partners	Unidentified	23 Florida Ave NE	Development land	N/A	25,000	7/2012	$66,682	ABBOTT DEVELOPMENT GROUP
1/2019	Kodiak Properties	Unidentified	1539 7th St NW	Mixed-use	$2.2 M	3,000	9/2010	$7,798	HMTR I, LLC
3/2019	Next Realty	Unidentified	Metropole	Condominiums	$4.8 M	N/A	7/2016	$18,934	NEBRASKA ALLIANCE REALTY

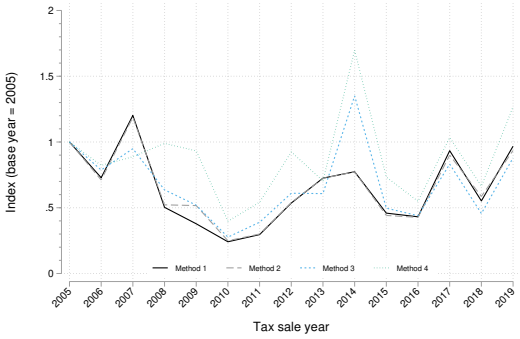
Repeat lien price index (total bid value)

Main deck

A. Institutional lien buyers



B. Individual lien buyers

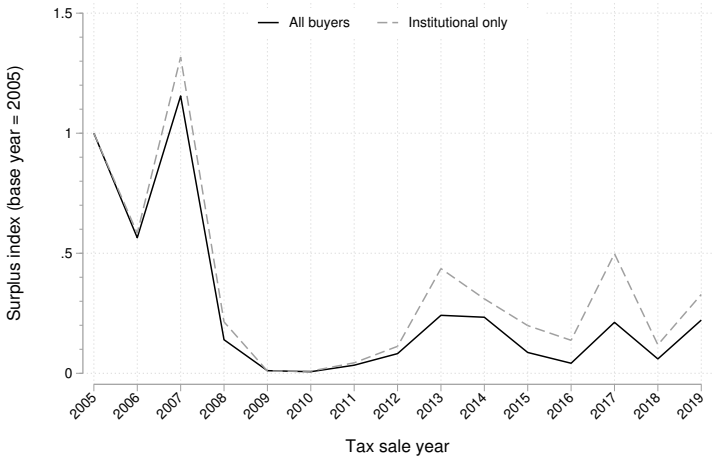


$$\log B_{i,t} = \delta_t + \gamma_m + \widetilde{\alpha}_i + \beta' \cdot \mathbf{X_{i,t}} + \epsilon_{i,t}$$

$$B_t = \exp(\delta_t)$$

Tax foreclosure option value index (surplus value)

Main deck



$$\log(1 + S_{i,t}) = \delta_t + \gamma_m + \widetilde{\alpha}_i + \beta' \cdot \mathbf{X_{i,t}} + \epsilon_{i,t}$$

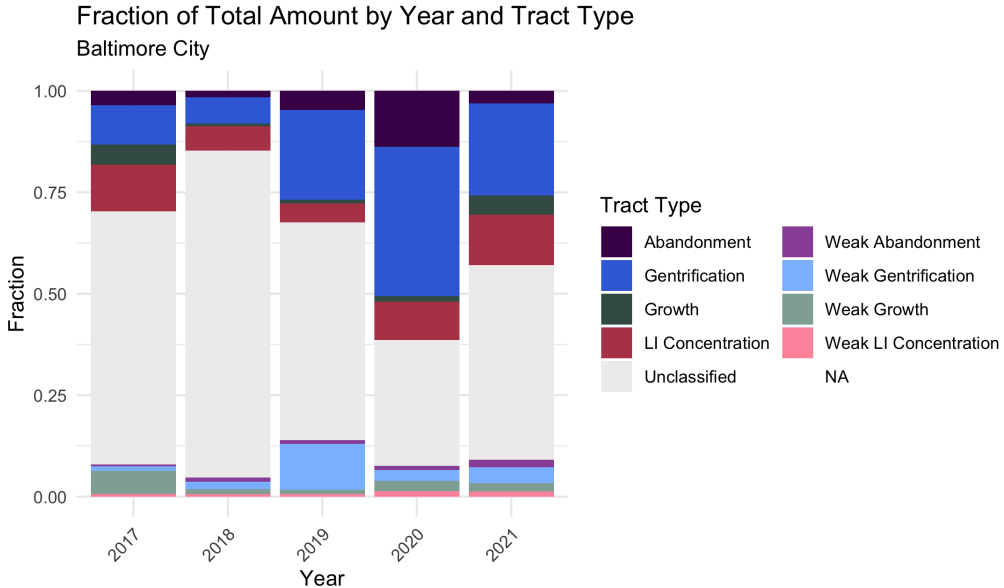
$$S_t = \exp(\delta_t)$$

- Matching estimator: $\widetilde{\alpha}_i$ address fixed effects (units within same building)
- Idea: surplus bid proxies for tax foreclosure option value because it does not accrue interest

Notes: $\widetilde{\alpha}_i$ are address fixed effects. All bid values in real 2012 dollars, converted from nominal terms using the PCE deflator.

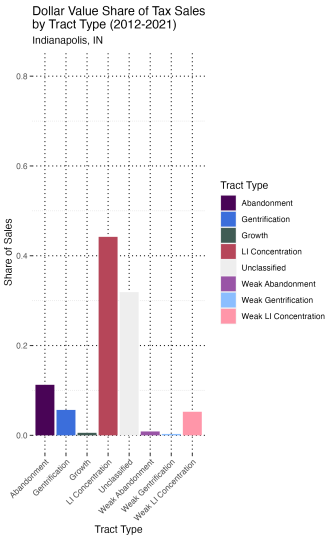
Targeting of gentrifying areas in Baltimore similar to D.C.

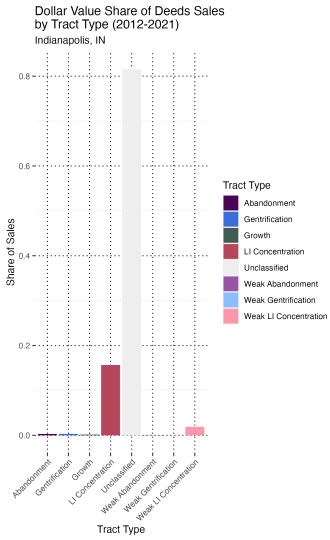
Main deck



Some targeting of gentrifying areas in Indianapolis

Main deck

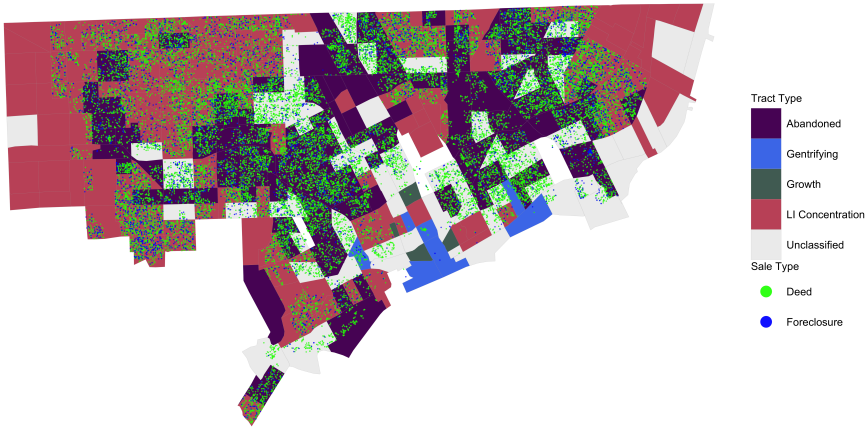




- Abandoned, gentrifying, and LI concentration tracts all over-represented relative to all arms-length, non-tax deed transactions
- **But gentrifying tracts are 5x over-represented**
- On a scale from D.C. to Detroit, cities like Indy which experienced bad subprime foreclosure crisis generally fall in the middle

Compare to the foreclosure crisis in Detroit...

Main deck



Source: Detroit Open Data Portal for 2012–2019.

- 85% of tax deed sales occur in low-income concentration/abandoned areas, many involving realty companies and non-profits

Geocoded data infrastructure

Main deck

- **Real estate data**
  - Proprietary databases: CoreLogic Tax/Deeds/Involuntary Liens, Zillow ZTRAX
  - Tax sale records: FOIA requested and scraped from local tax authorities when possible
  - Merge tax sale addresses to CoreLogic whenever possible to retrieve lat/lon, otherwise use Google Maps API $\longrightarrow$ determine ring positions
- **Business entry/exit and amenities**
  - ArcGIS Business Analyst (Shoag & Veuger 2018) + DnB/NETS database
  - Yelp public-use dataset for high frequency nowcasting
- **Census data**
  - IPUMS-NHGIS extracts from decennial Census and ACS on neighborhood demographics
  - State and local govt. finance data (ASSLGF + STC)

Tabulations: D.C. tax lien sales by buyer and area type

Main deck

	Pre-recession (2005-08)	Foreclosure crisis (2009-12)	Recovery (2013-19)	Total
Institutional + gentrifying	2,253	2,337	1,408	5,998
Individual + gentrifying	1,153	574	640	2,367
Institutional + non-gentrifying	2,118	2,375	1,748	6,241
Individual + non-gentrifying	1,525	650	859	3,304
Total	7,049	5,936	4,655	17,640

Source: D.C. Office of Tax & Revenue Buyer's Books (2005-2019). Tabulations exclude sales to non-profit buyers, or 4.2% of the sample (779 liens).

Method #1: "Naive" differences in ring means

Main deck

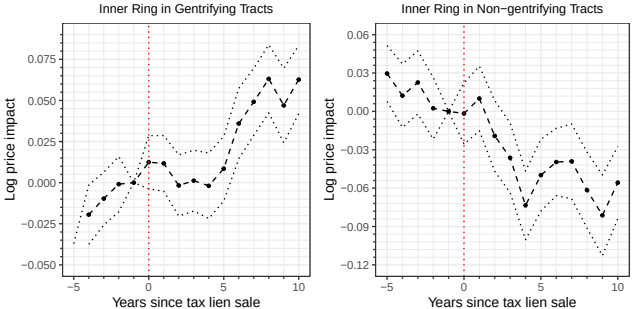
- Around each tax sale event, draw three rings and compute avg. price for properties within radius r miles: $R^{in}(r \leq 0.1)$, $R^{mid}(0.1 < r \leq 0.5)$, $R^{out}(0.5 < r \leq 1)$
- Then two sets of treatment effects by year:

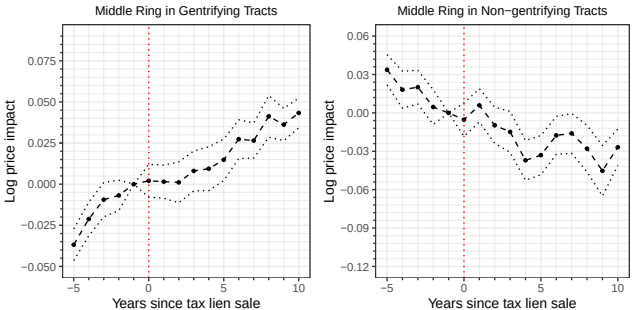
$$Inner\_treatment(T) = (R^{in}_{\ell,T} - R^{out}_{\ell,T}) - (R^{in}_{\ell,-1} - R^{out}_{\ell,-1}) \tag{3}$$

$$Middle\_treatment(T) = (R^{mid}_{\ell,T} - R^{out}_{\ell,T}) - (R^{mid}_{\ell,-1} - R^{out}_{\ell,-1}) \tag{4}$$

  - Differences between rings in T are relative to one year before the tax sale event in $T = 0$
  - Bin estimates at $t = -5$ and $t = +10$ to separate dynamic effects from secular time trends

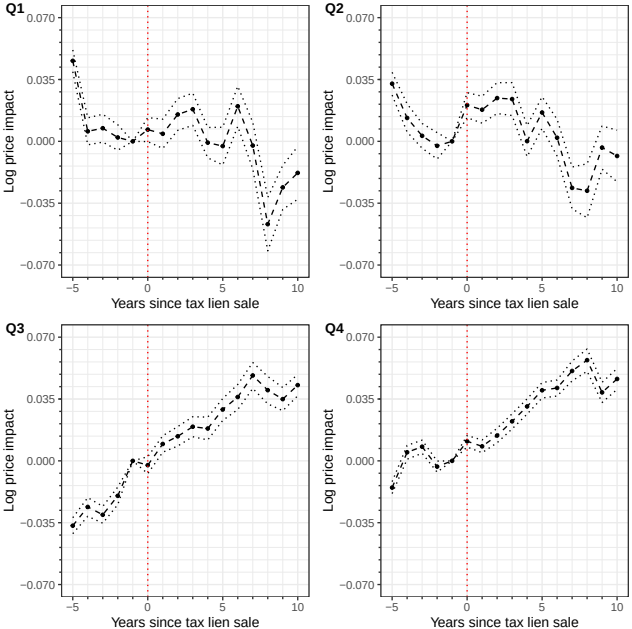
- Importantly, this method only takes out the year FEs, but not local time trends





- Prices pre-trend up (down) in (non-)gentrifying areas
- True for both middle and inner ring estimates
- Similar result if split rings by initial assessed value
- In gentrifying areas, inner ring estimates (+) drop off after around 0.5 mi.
  - No gradient w.r.t. distance in non-gentrifying areas (−)

Main deck

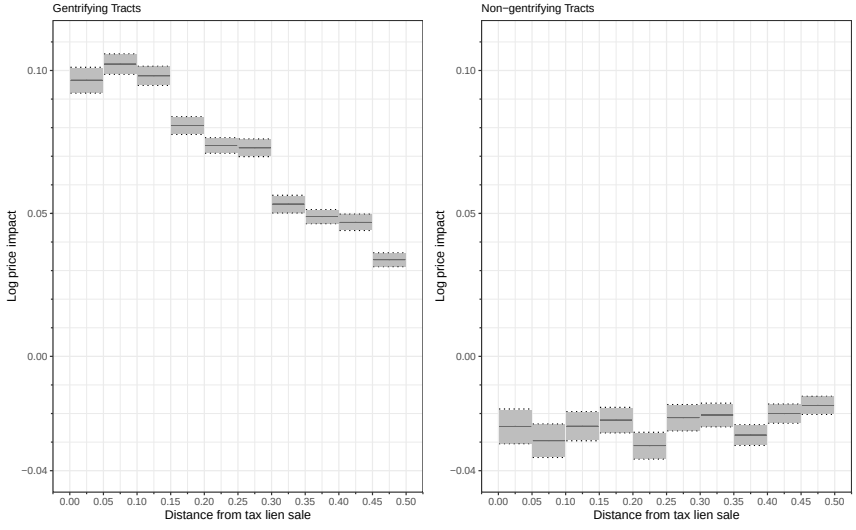


- Split middle rings by quartile of tax assessed value as of year prior to sample
- Tax assessed value from Zillow ZTRAX (CoreLogic doesn't go back that far)
- Similar trends to ring estimates split by gentrifying vs. non-gentrifying
- Additional evidence that tract type model based on flows picks up prices (revealed preference)

Main deck

Pooled inner ring estimates by distance to tax sale

Main deck



Notes: Each estimate compares average prices of homes sold in the inner ring within 0.1 miles of a tax sale property relative to an outer ring of properties 0.5 to 1 miles away, and pre vs. post-tax sale event. Unit prices winsorized at the 1st and 99th percentiles. 95% confidence intervals obtained via 1,000 block bootstrap iterations at the tax sale ring level.

Tracking ownership of tax lien properties

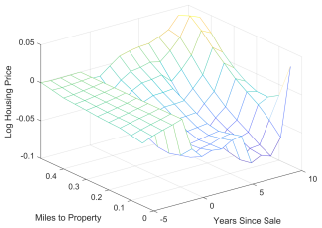
Main deck

- Starting with $N = 18{,}419$ D.C. tax lien sales, merge to CoreLogic and track subsequent title transfers beyond the 6 month redemption period
  - $\longrightarrow$ 8,693 of which have title changes after the redemption date
  - $\longrightarrow$ of these, 5,448 exchanged in arms-length transactions
  - $\longrightarrow$ of these, 2,146 transferred to institutional owner (event definition)
  - $\longrightarrow$ overall, only 14 exchanges to the mortgage lender
- Similar proportions if exclude repeat delinquencies, or use auction date as event cutoff
  - $\longrightarrow$ 868 transfers to institutional owners out of 4,368 title changes
  - Repeat delinquencies are a way for LLCs to retain the corporate veil
- $\Longrightarrow$ foreclosure rate conditional on tax lien sale is $868/8{,}693 \approx 10\%$

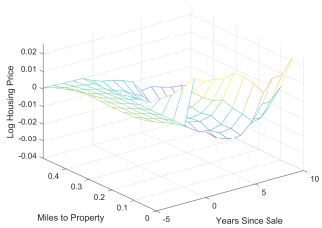
Heterogeneity by neighborhood type (individual buyers)

Main deck

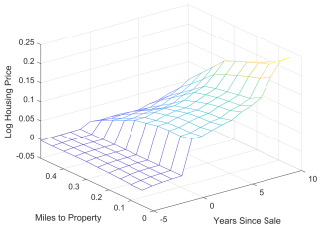
A. Sales in previously gentrifying tracts



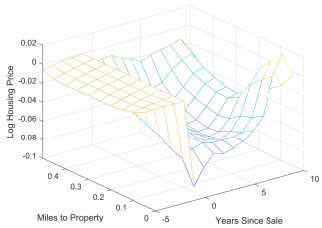
B. Sales in previously non-gentrifying tracts



C. Sales in recently gentrifying tracts



D. Sales in recently non-gentrifying tracts



- Similar effects in gentrifying areas for individual buyers
- Placebo: re-estimate pop. flows model to identify *ex ante* vs. *ex post* gentrification
  - *ex ante*: 1990 – 2005
  - *ex post*: 2005 – 2019
- Insignificant, non-monotonic responses in Panels A/B $\Longrightarrow$ investors not just amplifying pre-existing trends
- Non-monotonic responses in non-gentrifying areas, but no statistical significance

Pricing Effects of Tax Sales on Nearby Properties in Recently Gentrifying Tracts

Main deck

Distance (mi.) →	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5
Event time (years) ↓	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
−5	0.0012	−0.0013	−0.0018	−0.0017	−0.0017	−0.0012	−0.0013	−0.0012	−0.0013	−0.0010
	(0.0054)	(0.0040)	(0.0036)	(0.0034)	(0.0033)	(0.0031)	(0.0028)	(0.0024)	(0.0019)	(0.0012)
−4	0.0002	−0.0008	−0.0009	−0.0009	−0.0010	−0.0008	−0.0009	−0.0009	−0.0011	−0.0010
	(0.0030)	(0.0025)	(0.0023)	(0.0022)	(0.0021)	(0.0020)	(0.0018)	(0.0015)	(0.0012)	(0.0007)
−3	0.0003	−0.0003	−0.0004	−0.0004	−0.0005	−0.0004	−0.0005	−0.0005	−0.0007	−0.0007
	(0.0019)	(0.0016)	(0.0015)	(0.0014)	(0.0014)	(0.0013)	(0.0012)	(0.0010)	(0.0008)	(0.0005)
−2	0.0003	0.0000	0.0000	−0.0001	−0.0002	−0.0001	−0.0002	−0.0002	−0.0004	−0.0004
	(0.0010)	(0.0009)	(0.0008)	(0.0008)	(0.0008)	(0.0007)	(0.0006)	(0.0005)	(0.0004)	(0.0003)
1	0.0796***	0.0746***	0.0729***	0.0700***	0.0640***	0.0561***	0.0454***	0.0347***	0.0234***	0.0109***
	(0.0145)	(0.0125)	(0.0116)	(0.0110)	(0.0106)	(0.0101)	(0.0091)	(0.0079)	(0.0063)	(0.0042)
2	0.0808***	0.0767***	0.0753***	0.0724***	0.0664***	0.0584***	0.0472***	0.0360***	0.0240***	0.0111***
	(0.0143)	(0.0123)	(0.0115)	(0.0109)	(0.0106)	(0.0101)	(0.0091)	(0.0079)	(0.0063)	(0.0043)
3	0.0899***	0.0850***	0.0827***	0.0791***	0.0727***	0.0641***	0.0522***	0.0401***	0.0272***	0.0135***
	(0.0145)	(0.0125)	(0.0116)	(0.0110)	(0.0106)	(0.0101)	(0.0091)	(0.0079)	(0.0063)	(0.0042)
4	0.0997***	0.0931***	0.0900***	0.0854***	0.0785***	0.0691***	0.0560***	0.0426***	0.0286***	0.0140***
	(0.0143)	(0.0123)	(0.0115)	(0.0109)	(0.0106)	(0.0101)	(0.0091)	(0.0079)	(0.0063)	(0.0043)
5	0.1134***	0.1047***	0.1003***	0.0948***	0.0872***	0.0767***	0.0620***	0.0468***	0.0310***	0.0148***
	(0.0141)	(0.0123)	(0.0114)	(0.0109)	(0.0106)	(0.0101)	(0.0091)	(0.0079	(0.0064)	(0.0043
10	0.1683***	0.1585***	0.1502***	0.1408***	0.1283***	0.1124***	0.0905***	0.0688***	0.0470***	0.0237***
	(0.0187)	(0.0166)	(0.0158)	(0.0153)	(0.0147)	(0.0140)	(0.0123)	(0.0106)	(0.0086)	(0.0059)

Pricing Effects of Tax Sales on Nearby Properties in Recently Non-gentrifying Tracts

Main deck

Distance (mi.) →	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5
Event time (years) ↓	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
−5	0.0116**	0.0101**	0.0088**	0.0074*	0.0063*	0.0050	0.0031	0.0012	0.0002	−0.0002
	(0.0051)	(0.0047)	(0.0043)	(0.0040)	(0.0038)	(0.0035)	(0.0032)	(0.0028)	(0.0023)	(0.0014)
−4	0.0075**	0.0063**	0.0056**	0.0048*	0.0041*	0.0032	0.0020	0.0007	0.0000	−0.0002
	(0.0032)	(0.0029)	(0.0027)	(0.0025)	(0.0024)	(0.0022)	(0.0020)	(0.0017)	(0.0014)	(0.0009)
−3	0.0050**	0.0041**	0.0037**	0.0032*	0.0027*	0.0021	0.0013	0.0005	0.0000	−0.0001
	(0.0021)	(0.0019)	(0.0018)	(0.0017)	(0.0016)	(0.0014)	(0.0013)	(0.0011	(0.0009)	(0.0006)
−2	0.0027**	0.0022**	0.0020**	0.0018*	0.0015*	0.0012	0.0007	0.0003	0.0000	−0.0001
	(0.0012)	(0.0011)	(0.0010)	(0.0009)	(0.0009)	(0.0008)	(0.0007)	(0.0006)	(0.0005)	(0.0003)
1	−0.0461**	−0.0486***	−0.0523***	−0.0533***	−0.0528***	−0.0487***	−0.0423***	−0.0342***	−0.0248***	−0.0123**
	(0.0190)	(0.0169)	(0.0155)	(0.0146)	(0.0138)	(0.0132)	(0.0124)	(0.0112	(0.0093)	(0.0063)
2	−0.0424**	−0.0524***	−0.0577***	−0.0591***	−0.0584***	−0.0541***	−0.0476***	−0.0388***	−0.0280***	−0.0138**
	(0.0195)	(0.0173)	(0.0161)	(0.0152)	(0.0144)	(0.0138)	(0.0131)	(0.0120	(0.0101)	(0.0069)
3	−0.0499**	−0.0609***	−0.0676***	−0.0694***	−0.0684***	−0.0639***	−0.0572***	−0.0475***	−0.0354***	−0.0188**
	(0.0190)	(0.0169)	(0.0155)	(0.0146)	(0.0138)	(0.0132)	(0.0124)	(0.0112	(0.0093)	(0.0063)
4	−0.0535**	−0.0672***	−0.0747***	−0.0769***	−0.0759***	−0.0713***	−0.0645***	−0.0542***	−0.0409***	−0.0221**
	(0.0195)	(0.0173)	(0.0161)	(0.0152)	(0.0144)	(0.0138)	(0.0131)	(0.0120	(0.0101)	(0.0069)
5	−0.0624**	−0.0780***	−0.0858***	−0.0877***	−0.0865***	−0.0821***	−0.0753***	−0.0644***	−0.0497***	−0.0280**
	(0.0204)	(0.0184)	(0.0172)	(0.0162)	(0.0155)	(0.0149)	(0.0142)	(0.0132	(0.0113)	(0.0079)
10	−0.0503	−0.0740**	−0.0832**	−0.0918***	−0.0908***	−0.0849***	−0.0760**	−0.0625**	−0.0453*	−0.0252
	(0.0369)	(0.0356)	(0.0347)	(0.0321)	(0.0312)	(0.0305)	(0.0299)	(0.0288)	(0.0259)	(0.0188)

Pricing Effects of Tax Sales on Nearby Properties in Previously Gentrifying Tracts

Main deck

Distance (mi.) →	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5
Event time (years) ↓	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
−5	−0.0028**	−0.0085	−0.0106	−0.0118*	−0.0115*	−0.0104*	−0.0093*	−0.0085*	−0.0065*	−0.0034
	(0.0139)	(0.0079)	(0.0065)	(0.0062)	(0.0059)	(0.0055)	(0.0051)	(0.0045)	(0.0036)	(0.0023)
−4	−0.0046	−0.0069	−0.0075*	−0.0082*	−0.0080**	−0.0073**	−0.0066**	−0.0060**	−0.0046**	−0.0025*
	(0.0071)	(0.0048)	(0.0041)	(0.0039)	(0.0038)	(0.0035)	(0.0032)	(0.0028)	(0.0023)	(0.0014)
−3	−0.0038	−0.0048	−0.0051*	−0.0054**	−0.0052**	−0.0048**	−0.0044**	−0.0040**	−0.0031**	−0.0016*
	(0.0042)	(0.0031)	(0.0027)	(0.0026)	(0.0025)	(0.0023)	(0.0021)	(0.0019)	(0.0015)	(0.0010)
−2	−0.0023	−0.0028*	−0.0028*	−0.0029**	−0.0028**	−0.0026**	−0.0024**	−0.0021**	−0.0017**	−0.0009*
	(0.0021)	(0.0016)	(0.0015)	(0.0014)	(0.0014)	(0.0013)	(0.0012)	(0.0010)	(0.0008)	(0.0005)
1	0.0192	0.0054	−0.0040	−0.0077	−0.0069	−0.0034	0.0007	0.0046	0.0084	0.0096
	(0.0345)	(0.0284)	(0.0257)	(0.0240)	(0.0226)	(0.0213)	(0.0197)	(0.0176)	(0.0145)	(0.0097)
2	0.0257	0.0103	0.0002	−0.0034	−0.0026	0.0007	0.0044	0.0078	0.0105	0.0112
	(0.0359)	(0.0294)	(0.0267)	(0.0250)	(0.0237)	(0.0223)	(0.0208)	(0.0188)	(0.0157)	(0.0106)
3	0.0192	0.0054	−0.0040	−0.0077	−0.0069	−0.0034	0.0007	0.0046	0.0084	0.0096
	(0.0345)	(0.0284)	(0.0257)	(0.0240)	(0.0226)	(0.0213)	(0.0197)	(0.0176)	(0.0145)	(0.0097)
4	0.0257	0.0103	0.0002	−0.0034	−0.0026	0.0007	0.0044	0.0078	0.0105	0.0112
	(0.0359)	(0.0294)	(0.0267)	(0.0250)	(0.0237)	(0.0223)	(0.0208)	(0.0188)	(0.0157)	(0.0106)
5	0.0219	0.0073	−0.0029	−0.0064	−0.0054	−0.0022	0.0013	0.0046	0.0076	0.0103
	(0.0369)	(0.0304)	(0.0277)	(0.0261)	(0.0249)	(0.0235)	(0.0220)	(0.0201)	(0.0170)	(0.0117)
10	0.0624	0.0315	0.0159	0.0085	0.0032	−0.0013	−0.0031	−0.0014	0.0026	0.0079
	(0.0396)	(0.0372)	(0.0356)	(0.0343)	(0.0331)	(0.0316)	(0.0299)	(0.0279)	(0.0243)	(0.0171)

Pricing Effects of Tax Sales on Nearby Properties in Previously Non-gentrifying Tracts

Main deck

Distance (mi.) →	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5
Event time (years) ↓	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
−5	0.0056	0.0051	0.0051	0.0051	0.0049*	0.0046	0.0035	0.0022	0.0009	−0.0001
	(0.0039)	(0.0035)	(0.0033)	(0.0031)	(0.0029)	(0.0027)	(0.0025)	(0.0022)	(0.0017)	(0.0011)
−4	0.0037	0.0034	0.0034	0.0033*	0.0031*	0.0028	0.0020	0.0012	0.0003	−0.0003
	(0.0024)	(0.0022)	(0.0020)	(0.0019)	(0.0018)	(0.0017)	(0.0016)	(0.0013)	(0.0011)	(0.0007)
−3	0.0027*	0.0024*	0.0024*	0.0023*	0.0021*	0.0019*	0.0014	0.0008	0.0002	−0.0003
	(0.0016)	(0.0014)	(0.0013)	(0.0013)	(0.0012)	(0.0011)	(0.0010)	(0.0009)	(0.0007)	(0.0004)
−2	0.0016*	0.0014*	0.0014*	0.0014*	0.0012*	0.0011*	0.0008	0.0005	0.0001	−0.0002
	(0.0009)	(0.0008)	(0.0007)	(0.0007)	(0.0007)	(0.0006)	(0.0006)	(0.0005)	(0.0004)	(0.0002)
1	0.0225	0.0193	0.0168	0.0141	0.0102	0.0074	0.0041	0.0019	−0.0003	−0.0009
	(0.0142)	(0.0129)	(0.0120)	(0.0114)	(0.0109)	(0.0103)	(0.0094)	(0.0082)	(0.0067)	(0.0045)
2	0.0237*	0.0171	0.0138	0.0112	0.0078	0.0053	0.0021	0.0002	−0.0015	−0.0017
	(0.0142)	(0.0131)	(0.0122)	(0.0116)	(0.0111)	(0.0106)	(0.0097)	(0.0086)	(0.0070)	(0.0048)
3	0.0225	0.0193	0.0168	0.0141	0.0102	0.0074	0.0041	0.0019	−0.0003	−0.0009
	(0.0142)	(0.0129)	(0.0120)	(0.0114)	(0.0109)	(0.0103)	(0.0094)	(0.0082)	(0.0067)	(0.0045)
4	0.0237*	0.0171	0.0138	0.0112	0.0078	0.0053	0.0021	0.0002	−0.0015	−0.0017
	(0.0142)	(0.0131)	(0.0122)	(0.0116)	(0.0111)	(0.0106)	(0.0097)	(0.0086)	(0.0070)	(0.0048)
5	0.0223	0.0144	0.0097	0.0068	0.0037	0.0012	−0.0020	−0.0037	−0.0049	−0.0040
	(0.0143)	(0.0132)	(0.0124)	(0.0119)	(0.0114)	(0.0109)	(0.0101)	(0.0091)	(0.0076)	(0.0052)
10	0.0371*	0.0233	0.0155	0.0111	0.0072	0.0042	−0.0011	−0.0043	−0.0057	−0.0064
	(0.0217)	(0.0206)	(0.0201)	(0.0198)	(0.0195)	(0.0191)	(0.0184)	(0.0175)	(0.0154)	(0.0108)

Method #3: implementation of the ED method

Main deck

- House prices around tax sale property S follow:

$$\log(p_{i,t}) = m_S(d_i, \tau_i) + \phi_S(d_i, \theta_i) + \gamma_S(\theta_i, t_i) + \varepsilon_{i,t} \tag{5}$$

  - i relates to S in polar coordinate plane (d, θ)
  - τ_i number of years since the tax sale transfer
  - $\phi_S(\cdot)$ and $\gamma_S(\cdot)$ allow house prices to vary across locations and trend differently across time in multiple directions
  - $m_S(\cdot)$ is the two-dimensional empirical derivative of interest

- Find partial derivative of $p_{i,t}$ w.r.t. d, holding θ_i and t_i fixed, by computing:

$$\frac{\log(p_{d-\delta,\theta,t}) - \log p_{d+\delta,\theta,t}}{2\delta}, \quad \text{for } \delta > 0$$

- Iteratively compare properties $d - \delta$ and $d + \delta$ from S to difference out the local effects (take a bunch of diff-in-diff pairs)

Calibration details for empirical derivatives estimator

Main deck

- The empirical derivatives estimator is semi-parametric in that researchers must still choose six tuning parameters:
  1. $h_{r,n}$: smoothing in distance (miles)
  2. $h_{t,n}$: smoothing in time (years)
  3. g_n^t bowtie search area width in time
  4. g_n^θ bowtie search area width in polar distance
  5. κ_n: max # of house price pairs included in bowtie
  6. r: ring radius within which to trace out the derivative

- Compared to two other papers using this method, I use smaller r and $h_{r,n}$
  - Tax sales more numerous and geographically clustered
  - Results largely robust to choices of tuning parameters

Alternative Tuning Parameters for Empirical Derivatives Estimator

Main deck

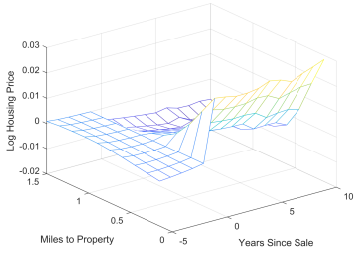
	(I)	(II)	**(III)**	(IV)	(V)	(VI)
Smoothing parameters						
$h_{r,n}$ (smoothing in miles)	0.300 mi.	0.200 mi.	0.125 mi.	0.125 mi.	0.100 mi.	0.250 mi.
$h_{t,n}$ (smoothing in years)	5 years	5 years	5 years	3 years	3 years	1.5 years
Bowtie dimensions						
g_n^t (width in years)	1.6 years	1.6 years	1.6 years	1.6 years	1.6 years	1.6 years
g_n^θ (width in polar distance)	0.4	0.4	0.4	0.4	0.4	0.4
Sample selection						
κ_n (# price pairs)	5 pairs	5 pairs	5 pairs	8 pairs	5 pairs	5 pairs
ℓ_n (excluded zone)	0.01 mi.	0.01 mi	0.01 mi.	0.01 mi.	0.01 mi.	0.01 mi.
r (ring radius)	1.5 mi.	1 mi.	0.5 mi.	0.5 mi.	0.5 mi.	0.33 mi.

Notes: Column (I) corresponds to the set of parameters used in Diamond & McQuade (2019). Column (VI) corresponds to the parameters used in Ganduri & Maturana (2022). I use the set of parameters in column (III) in establishing my main results.

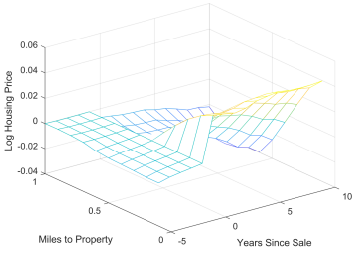
Price surface w.r.t. tuning parameter sets (gentrifying)

Main deck

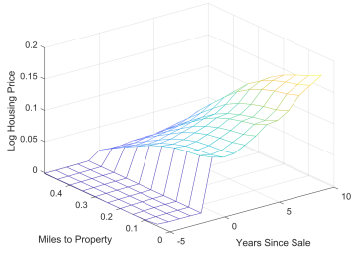
(I)



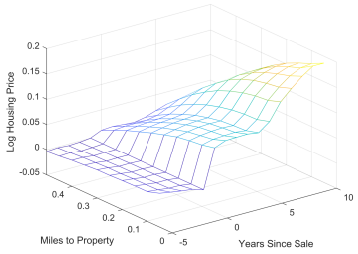
(II)



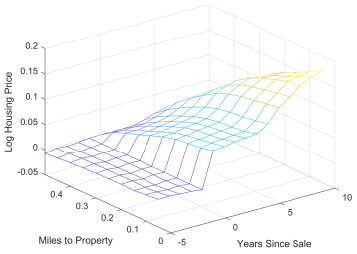
(III)



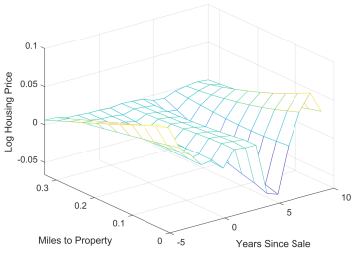
(IV)



(V)



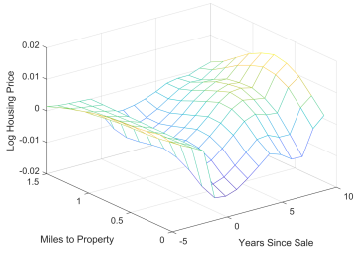
(VI)



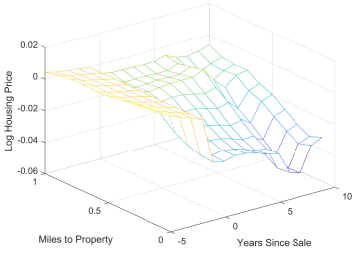
Price surface w.r.t. tuning parameter sets (non-gentrifying)

Main deck

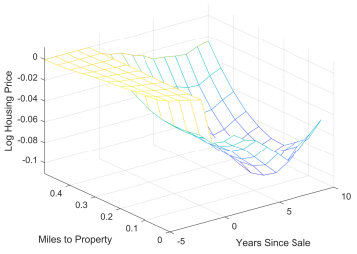
(I)



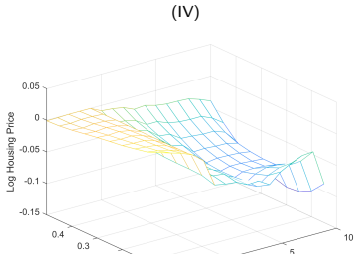
(II)



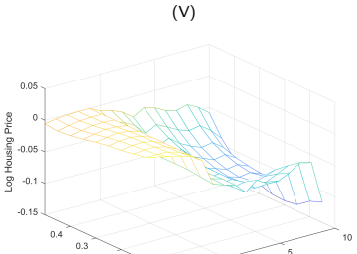
(III)



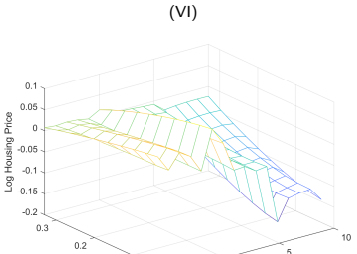
(IV)



(V)



(VI)



Imputing homeowners' racial identities

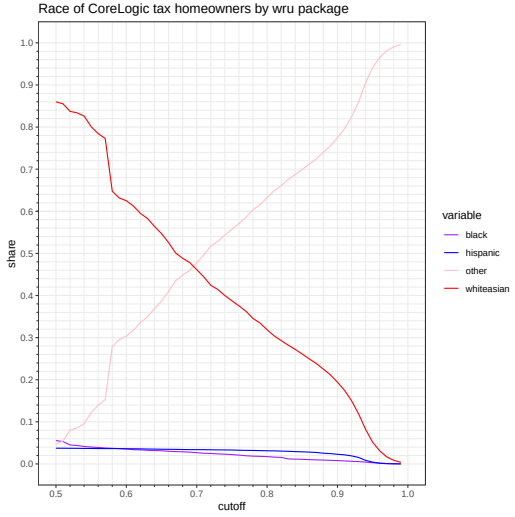
To liens | Main deck

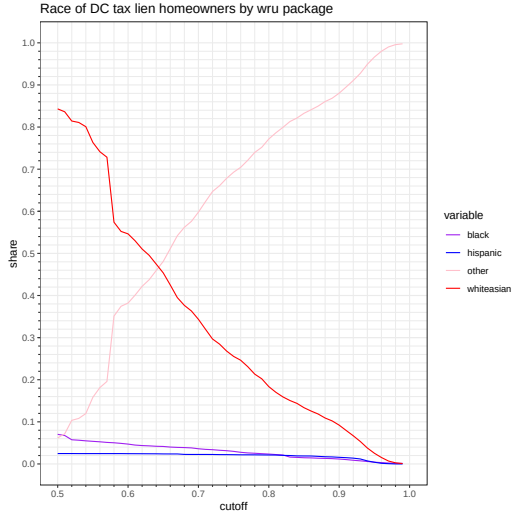
- Use `wru` R package developed by Imai & Khanna [IK] (2016)
  - Infer racial category $\mathcal{R}$ using location ℓ and surname $\mathcal{S}$ in Census surname list
- Then estimate $\widetilde{p} \equiv \Pr(R_i = \mathcal{R} | L_i = \ell, S_i = \mathcal{S})$ via Bayes's rule
  - Assumes location and surname statistically independent conditional on race, or $L_i \perp\!\!\!\perp S_i | R_i$
- Try three definitions of racial category probability
  1. Set $URM = 1$ if $\widetilde{p} > 0.5$ for Black or Hispanic
  2. Set $URM = 1$ if highest probability race is Black or Hispanic (exactly follows IK)
  3. Continuous Bayesian probability that race is either Black or Hispanic

High correlation with L2 voter registration data at block group level

Robustness of racial classification to probability cutoff

Main deck

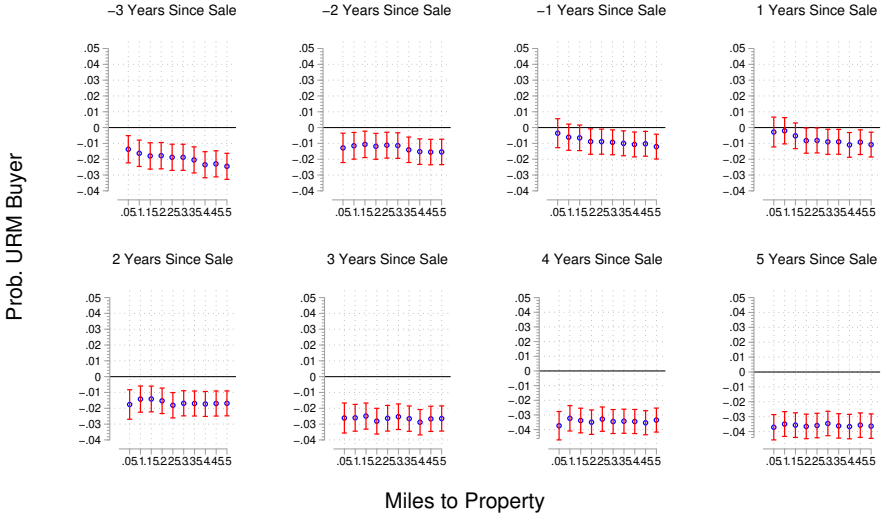




- "Other" includes surnames with majority Native American, multi-racial respondents, and any rare surnames not in the Census surname list

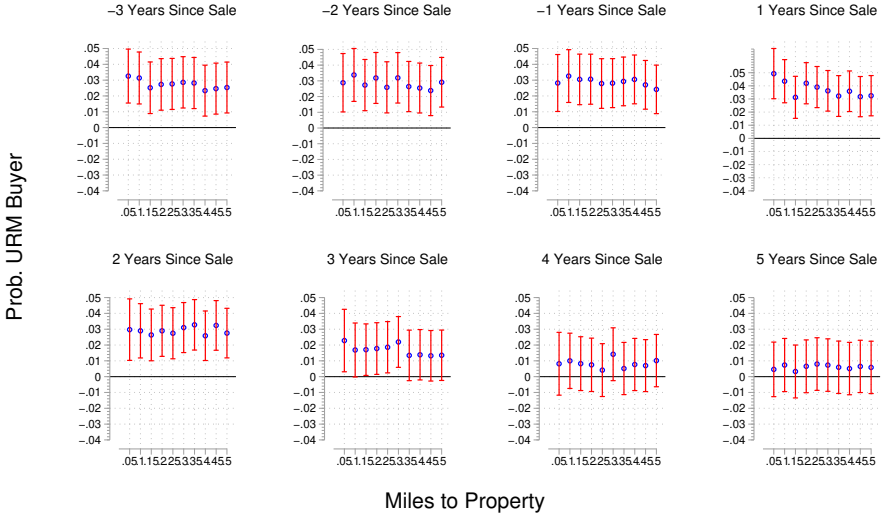
Similar story for continuous URM buyer prob. measure...

Main deck



No (−) effect on URM buyer dummy for ind. tax liens

Main deck

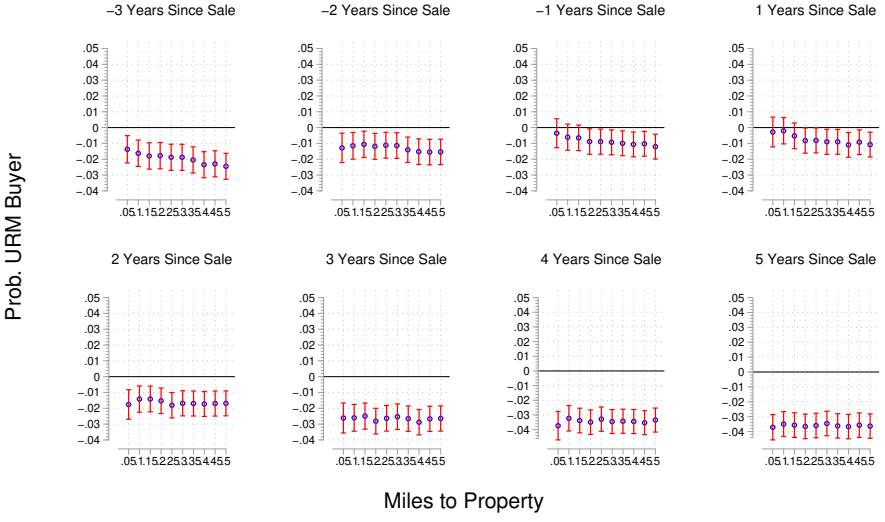


Weaker effect on URM buyer prob. for ind. tax liens

Main deck

Big drop in URM seller prob. as well, but some pre-trend

Main deck

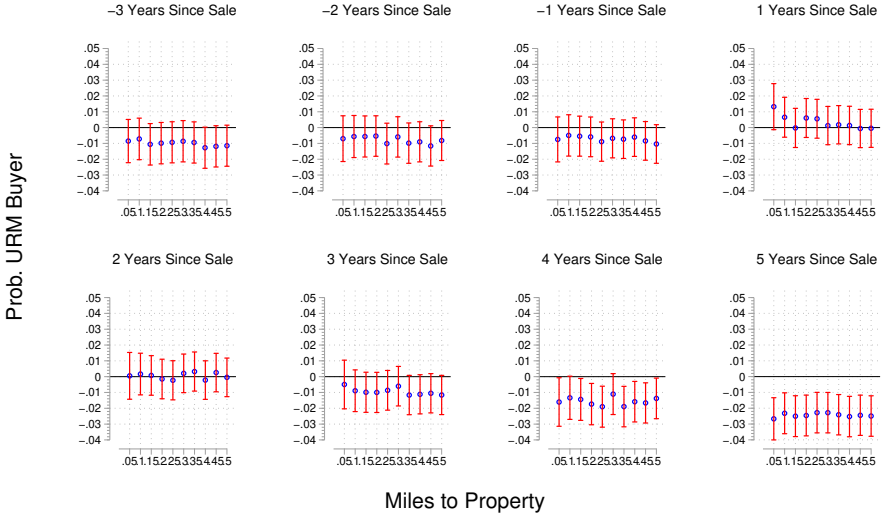


No (−) effect on URM seller dummy for ind. tax liens

Main deck

Also not much effect on URM seller prob. for ind. tax liens

Main deck



Two-Stage Gentrification Model

What is gentrification?

To maps To 3D plots

- Deep question debated in sociology since the 1980s
- Two main strands of sociological models taken to data:
  1. **"Stage" models** (Marcuse 1985, 1986): layered sort of geographic areas into four categories
     - ⋆ Abandonment, gentrification, growth, low income concentration
  2. Risk aversion models (Gale 1979; Kerstein 1990): persistence of gentrification depends on migrants' risk attitudes towards amenity preservation

What is gentrification?

To maps To 3D plots

- Deep question debated in sociology since the 1980s
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  1. **"Stage" models** (Marcuse 1985, 1986): layered sort of geographic areas into four categories
     - ⋆ Abandonment, gentrification, growth, low income concentration
  2. Risk aversion models (Gale 1979; Kerstein 1990): persistence of gentrification depends on migrants' risk attitudes towards amenity preservation
- Contrast to the urban economics literature which tries to model within-metro sorting through **utility maximization problems**
  - Brueckner & Rosenthal (2009); Guerrieri, Hartley, Hurst (2013); Lee & Lin (2018); Couture & Handbury (2019); Murphy (2021); Su (2022)
  - Econ state variables often used as factor sorts in the sociological stage models

Stage model helps reconcile sociology and urban econ

To maps To 3d plots

- Generalization of stage model adopted by UMN Institute on Metropolitan Opportunity
  - I generalize and apply the model to all U.S. Census tracts over 1990–2005 and 2005-2019
- Intuition for each sorting stage:
  1. **1st stage:** sort areas based on strength of local economy (i.e. in-migration)
  2. **2nd stage:** further sort based on ability to accommodate low-income pop. growth
- High/low income population shares form a **sufficient statistic** for local economic performance as in standard $V = Z \cdot W/P^{\beta}$ sorting condition
  - Few assumptions, but results consistent with more complicated sorts (e.g. housing prices)
- Use of thresholds reminiscent of Schelling's (1971, 1978) **tipping point** theory

Crosswalk State correl US 4-type map US 8-type map Robustness Persistence

Model completely governed by three threshold parameters

- Model characterized by a vector $\mathbf{x} := \{x_1, x_2, x_3\}$
  - x_1 [1st stage]: % change in non-low-income residents
  - x_2 [1st stage]: p.p. change in low-income population share
  - x_3 [2nd stage]: % change in low-income residents

- **Robustness:** check how maps change as I iterate over values in $\mathbf{x}$
  - Baseline: select x_1, x_2 to match avg. tipping points observed within metro area
  - Exercise complements race-based RD-style tests in Bayer, Fang, & McMillan (2014)

- Examine neighborhood "persistence" under two definitions:
  - *Type persistence*: prob. tract type is exactly the same in subperiod t and $t+1$
  - *Gentrification persistence*: correlation of dummy for weak/strong gentrifying (under $\underline{\mathbf{x}}$ vs. $\bar{\mathbf{x}}$) between t and $t+1 \longrightarrow$ corr $\approx 0 \implies$ long-run steady state

Transition matrix: gentrification rarely followed by reversals

	Abandonment	*Gentrification*	*Growth*	*LI Concentration*	*Unclassified*
Abandonment	**0.47%**	0.58%	0.15%	0.13%	2.02%
Gentrification	0.37%	**2.33%**	0.75%	1.46%	4.48%
Growth	0.17%	0.79%	**0.64%**	0.54%	2.51%
LI Concentration	0.53%	1.52%	0.033%	**6.95%**	6.45%
Unclassified	1.59%	9.69%	3.43%	14.18%	**36.76%**

Notes: Rows indicate the initial tract type in 1990-2005, while columns indicate the more recent tract type in 2005-2019.

- 1/4 of initially *gentrifying* continue to gentrify, while 48% reach the steady state represented by *unclassified*
- Only 19% of *gentrifying* tracts reverse course to become *abandoned* or *LIC*

Details on Census crosswalking procedures

Go back

- Standard procedures following Opportunity Atlas of Chetty et al. (2018)
- Convert variable $X_{j,t}$ between 2000 tract j and 2010 tract k via:

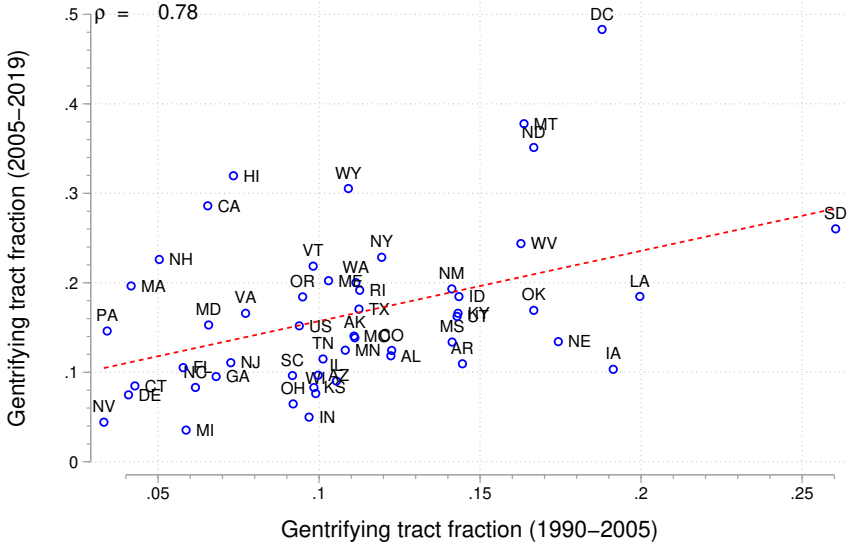
$$X_{k,t} = \sum_{j \subseteq k} \omega_j \cdot X_{j,t}$$

$$\omega_j = \frac{\text{2010 population of overlap}}{\text{2010 population of the 2000 tract}}$$

- Map 1990 tracts to 2010 using similar procedure: first reweight from 1990 to 2000 geography, then reweight to go from 2000 to 2010
- Can also aggregate from block group level but more missing values

At state level, gentrification persistent over 30-year period

Go back



County-level mapping of gentrification (4-type model)

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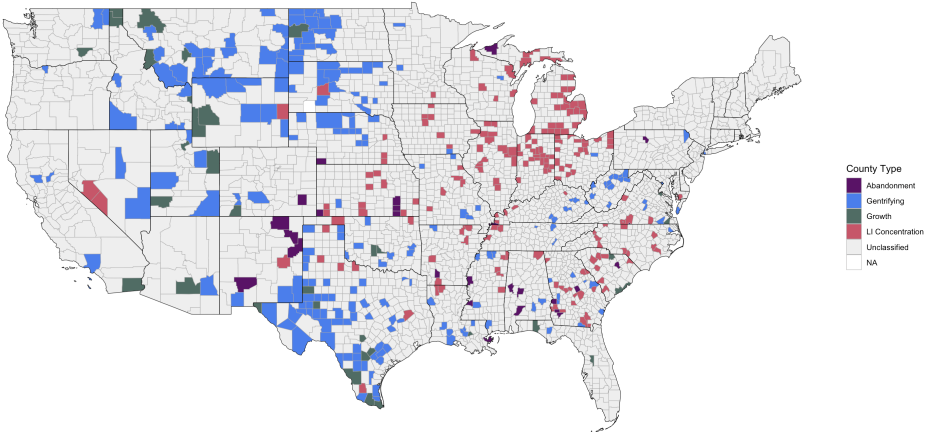

- Using "strong" cutoff parameters $\{\overline{x_1}, \overline{x_2}, \overline{x_3}\} = \{10\%, 5\text{p.p.}, 0\%\}$, where unclassified means demographic change is sufficiently minimal

County-level mapping of gentrification (8-type model)

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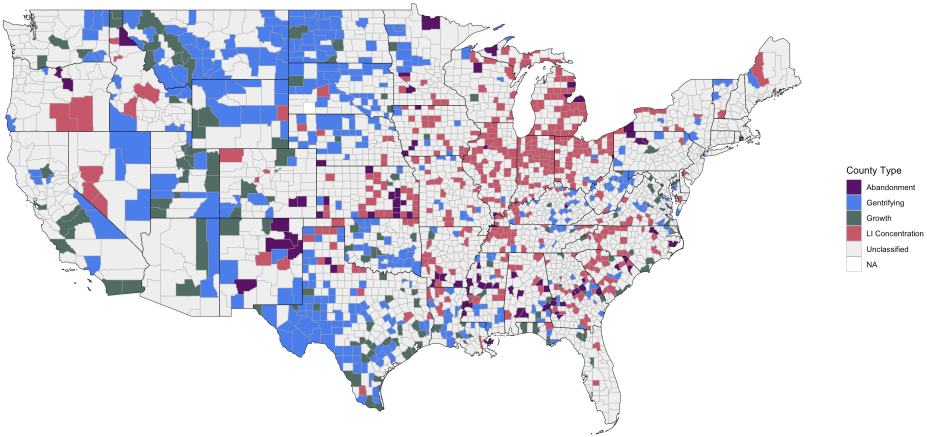
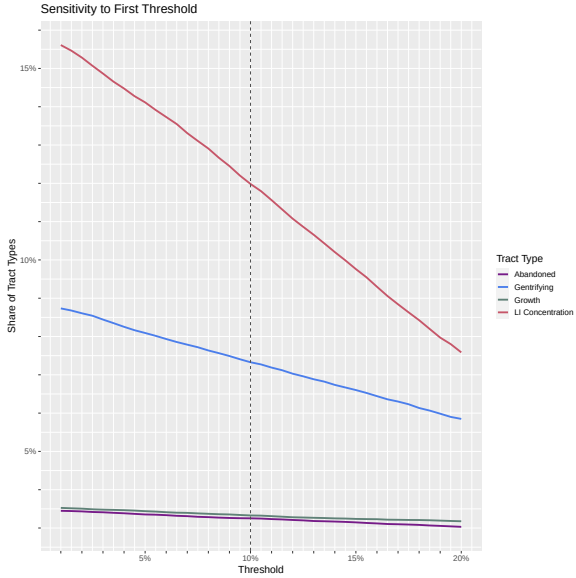
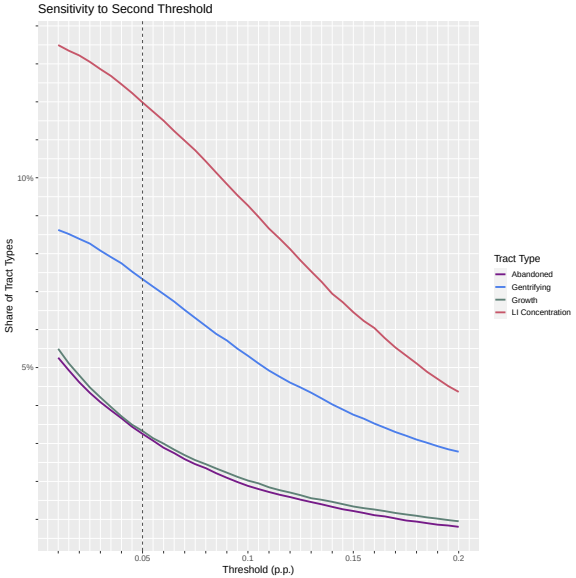


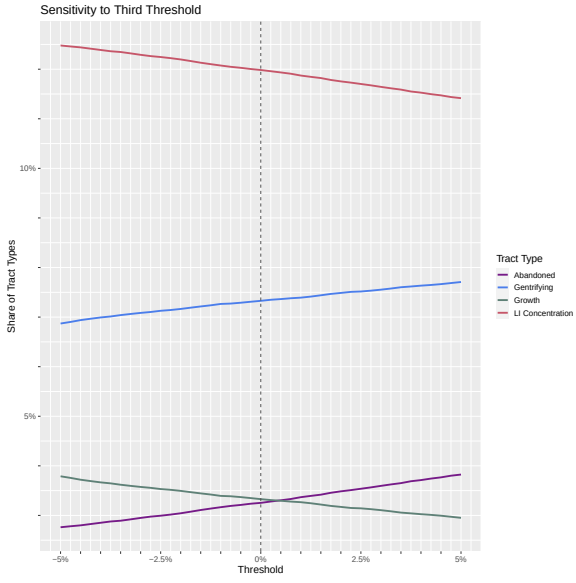
- Using "weak" cutoff parameters $\{\underline{x_1}, \underline{x_2}, \underline{x_3}\} = \{5\%, 2.5\text{p.p.}, 0\%\}$ and lumping weak and strong types together


Sensitivity to First Threshold
Share of Tract Types
15%
10%
5%
5%
10%
15%
20%
Threshold
Tract Type
Abandoned
Gentrifying
Growth
LI Concentration

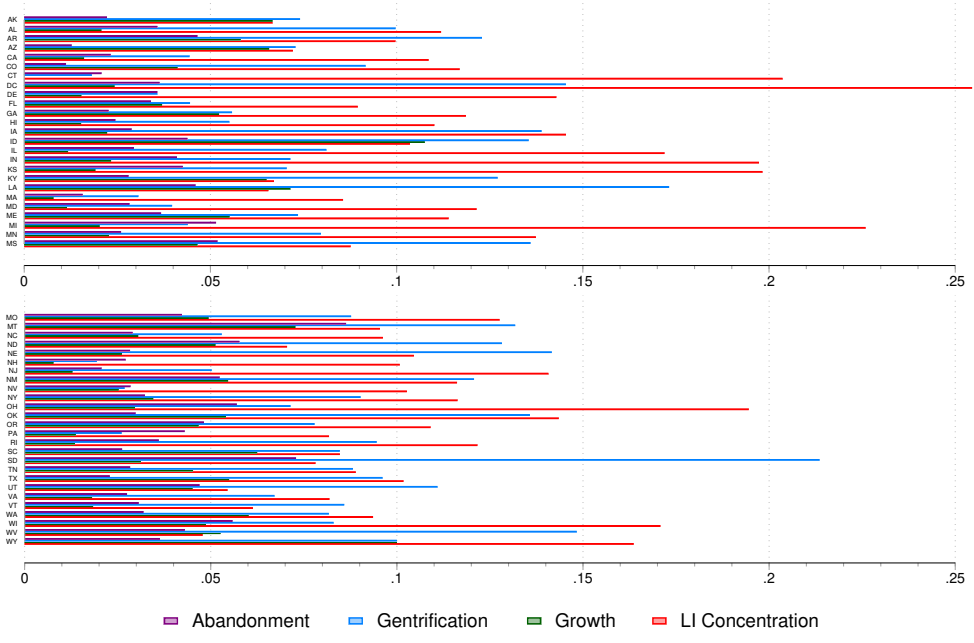

Sensitivity to Second Threshold
Share of Tract Types
10%
5%
0.05
0.1
0.15
0.2
Threshold (p.p.)
Tract Type
Abandoned
Gentrifying
Growth
LI Concentration

Comments on robustness to threshold parameters

Go back



- Tract type probabilities all decreasing with respect to x_1 and x_2 first stage thresholds
  - More stringent definition of neighborhood change $\implies$ more tracts unclassified
- Abandonment/gentrification move in opposite direction of LIC/growth w.r.t. x_3 since former are about low-income population population decline
- In practice, pick parameters to match tipping points observed for each metro area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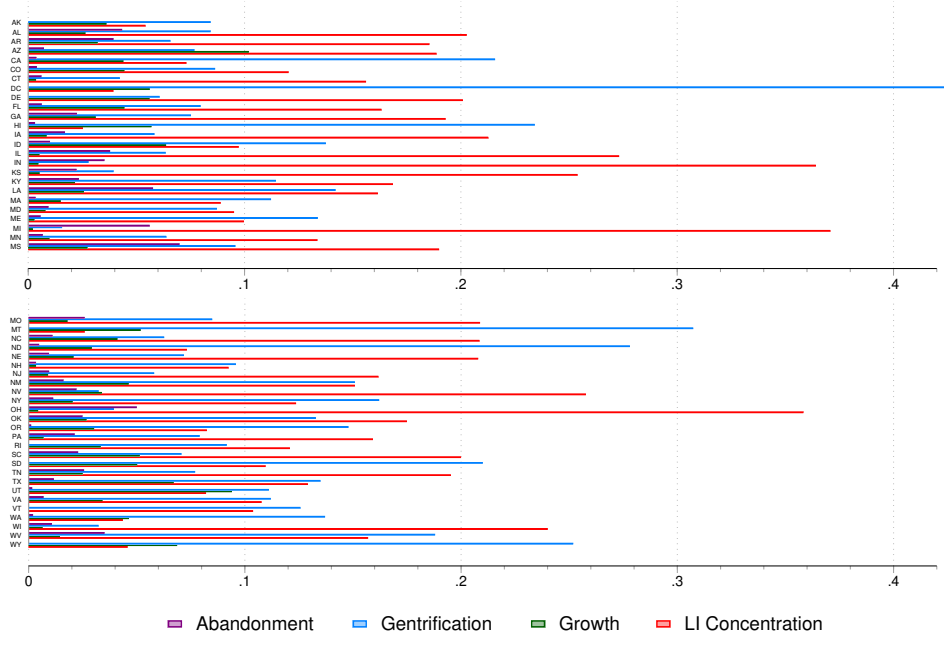
Growth
LI Concentration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Long-run Gentrification Persistence by State

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