Who signs up for free raingardens? Distributional effects of green stormwater infrastructure subsidies

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Social Cost of Water Pollution
2021

Primary Questions

1. Who signs up for green stormwater infrastructure (GSI) subsidies?
2. What are the distributional impacts of GSI policies?
3. IN PROGRESS: What is the role of peer effects in GSI adoption?
4. ~~What are the implications of participation (selection) on estimating capitalization effects?~~

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Motivation

How does this fit into broader assessment of social cost of water pollution using IAMs?

- Voluntary programs are a major component of water quality improvement policies (e.g. ag BMPs, urban GSI, etc.)
- Understanding voluntary adoption behavior is essential to:
  1. predict where adoption occurs
  2. understand the implications of adoption behavior on water quality outcomes
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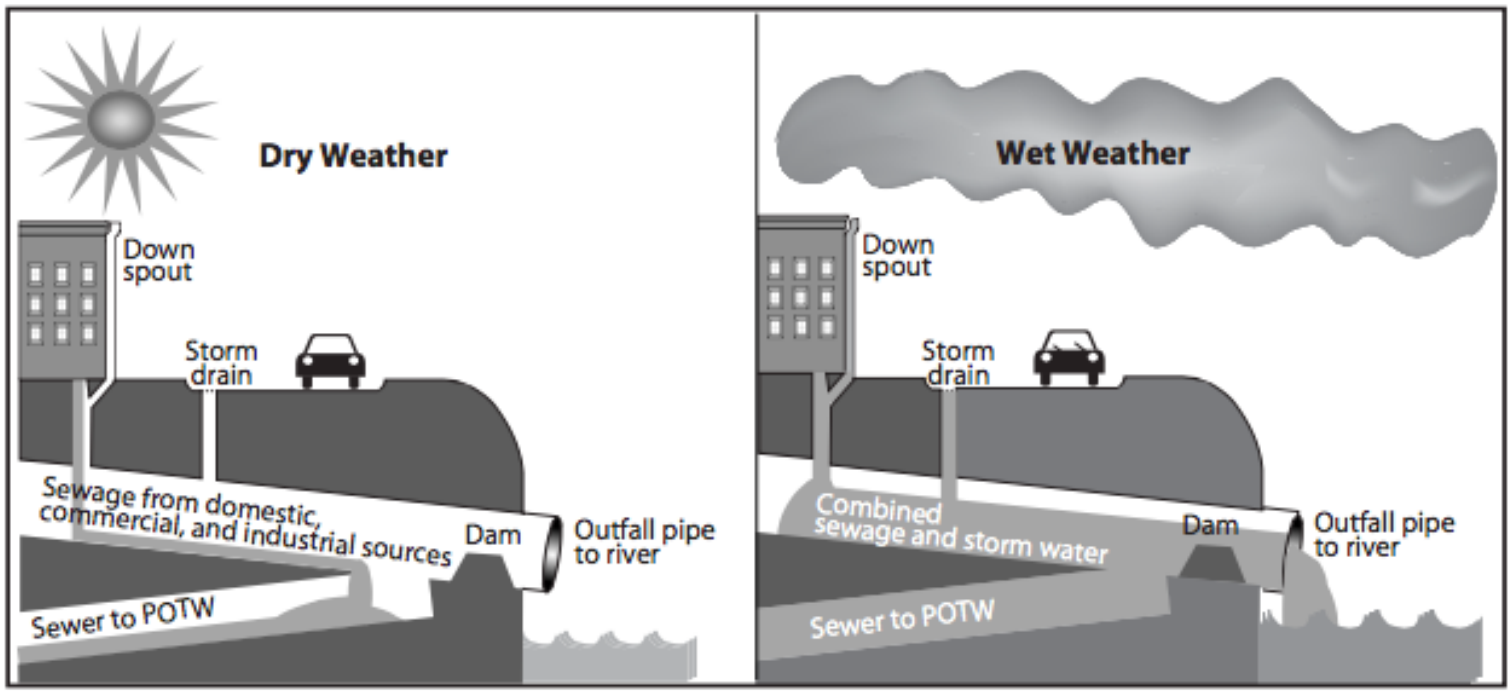
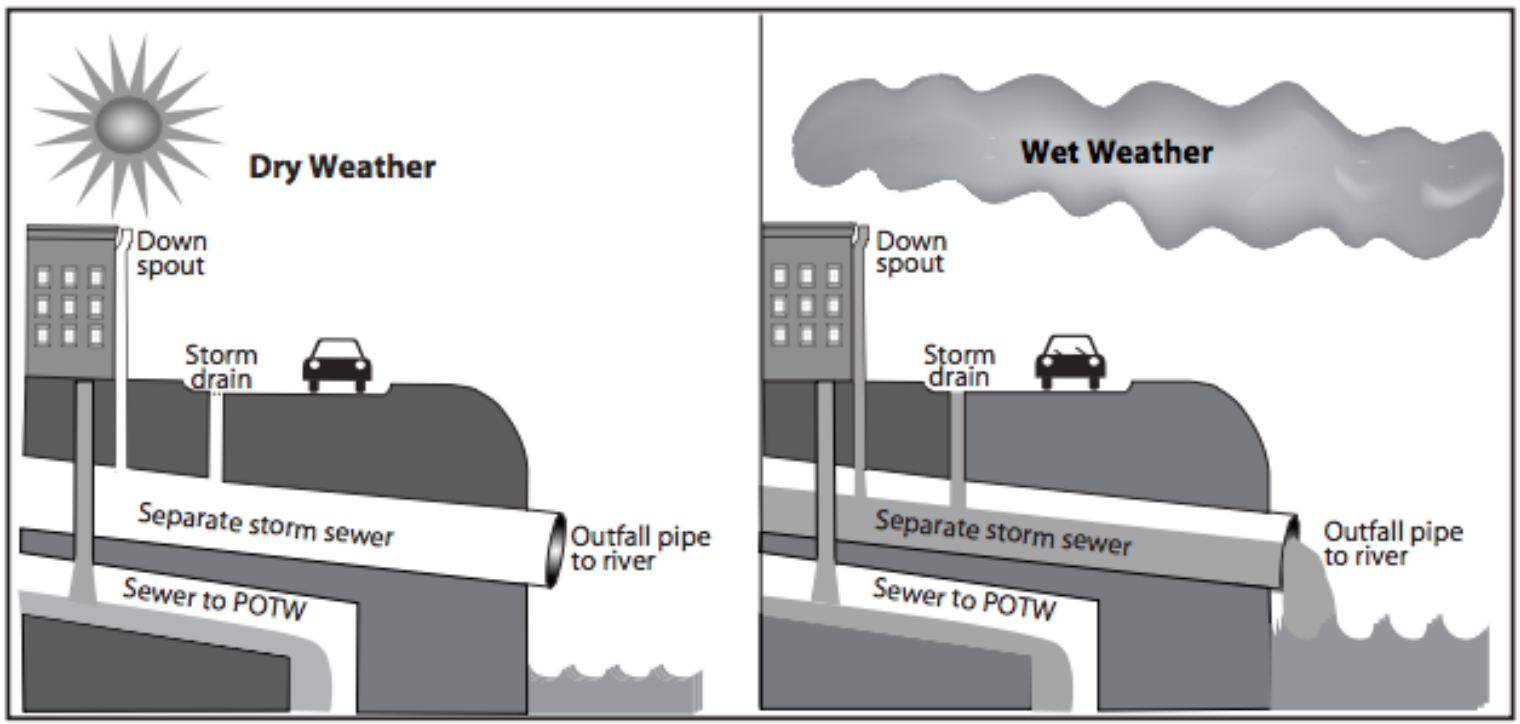
Green Infrastructure for CSOs

Combined Sewer System



Green Infrastructure for CSOs

Separate Sewer System



Green Infrastructure for CSOs

Figure 4: Types of Green Infrastructure Illustrated on the Environmental Protection Agency's Website

Billion Dollar Consent Decrees

- Pittsburgh
- DC
- Atlanta
- Cincinnati (+Erlanger County)
- Indianapolis
- Chicago
- Cleveland
- St. Louis
- Kansas City
- Seattle (+King County)

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`https://www.epa.gov/green-infrastructure/enforcement`

Literature Review

1. Cost Effectiveness
   - Montalto et al. (2007)
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Seattle and King County

Violations of the Clean Water Act (CWA)

- King County (KC) discharged approximately 900 million gallons of raw sewage annually from 2006-2010
- Seattle discharged approximately 200 million gallons of raw sewage annually from 2006-2010

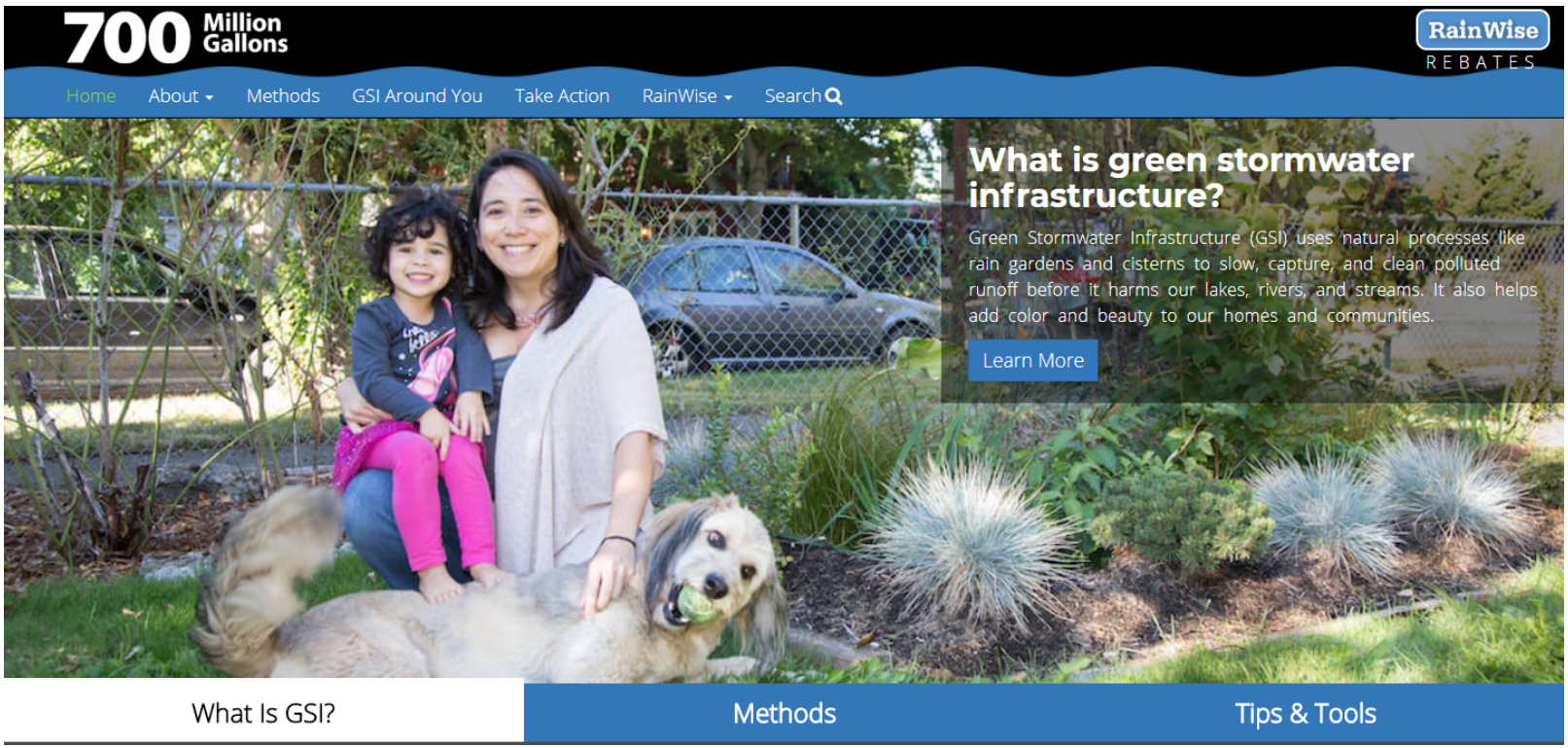
Injunctive relief

- KC must reduce CSO by 95-99% by 2030 - estimated cost is $860 million
- Seattle must reduce CSO by 99% by 2030 - estimated cost is $600 million

Green Infrastructure for CSOs

- Both KC and Seattle were permitted to use an integrated planning incorporating green stormwater infrastructure (GSI) to reduce pollution
- They also both have an environmental justice component to their plan because CSO discharge affect environmental justice communities

700 million gallons



700 million gallons

Three components

1. RainWise - private voluntary raingardens and/or cisterns
2. Mandatory GSI - required on private land when new impervious surface is added (new construction and renovations)
3. Public GSI - GSI built and maintained by public agencies (parks, transportation, etc) on public land

We focus on RainWise to model private landowners' *choice* to install GSI

Rainwise

Manage your rain water at home

What's the problem?

With every storm, rain carries pollutants off our roofs, driveways and other hard surfaces to local creeks, Lake Washington and Puget Sound. During big storms, the sheer volume of this "stormwater" can cause sewer overflows, and erode hillsides and stream banks. Rain gardens and cisterns can help control this stormwater with your help.

RainWise contractors design rain gardens that fit the unique needs of each site.

Steps to becoming RainWise

Go to *www.rainwise.seattle.gov*

1. **Check your eligibility** by typing in your address to find out what will work on your property and if you can get a rebate.
2. **Get bids** from trained contractors in the "Find a Contractor" section of the website. Choose your contractor.
3. **Your contractor will schedule a pre-inspection** for approval to build and then install your system.
4. **Your contractor will schedule a final inspection.** A RainWise inspector will confirm that your installation was done properly.
5. **Get your rebate!** Submit your rebate package and receive your rebate within 6-8 weeks.

RainWise REBATE$!
RainWise will pay for rain gardens and cisterns

Rainwise

The Rebate Process

The RainWise Program provides rebates that cover most or all of the cost of installing cisterns and rain gardens on your property. To receive a rebate, you must be in an eligible combined sewer overflow (CSO) basin and work with a RainWise-trained contractor. The rebate can be up to $4.00 per square foot of rooftop runoff controlled.

The average rebate has been $4,800 and on average, 90% of the project is covered. Talk to your contractor about what you can do on your property and ways to maximize the rebate.

RainWise Info Flyer (english)

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Environmental Justice

- Rebates are financed by all ratepayers, and flow to participating households
- Anecdotal evidence of mostly high income areas and households participating
  - A concern of policymakers
- If GSI is capitalized into housing values this is a transfer of wealth from all ratepayers to wealthier participants
- Resources (low cost loans, additional funding) for low-income and under-served communities

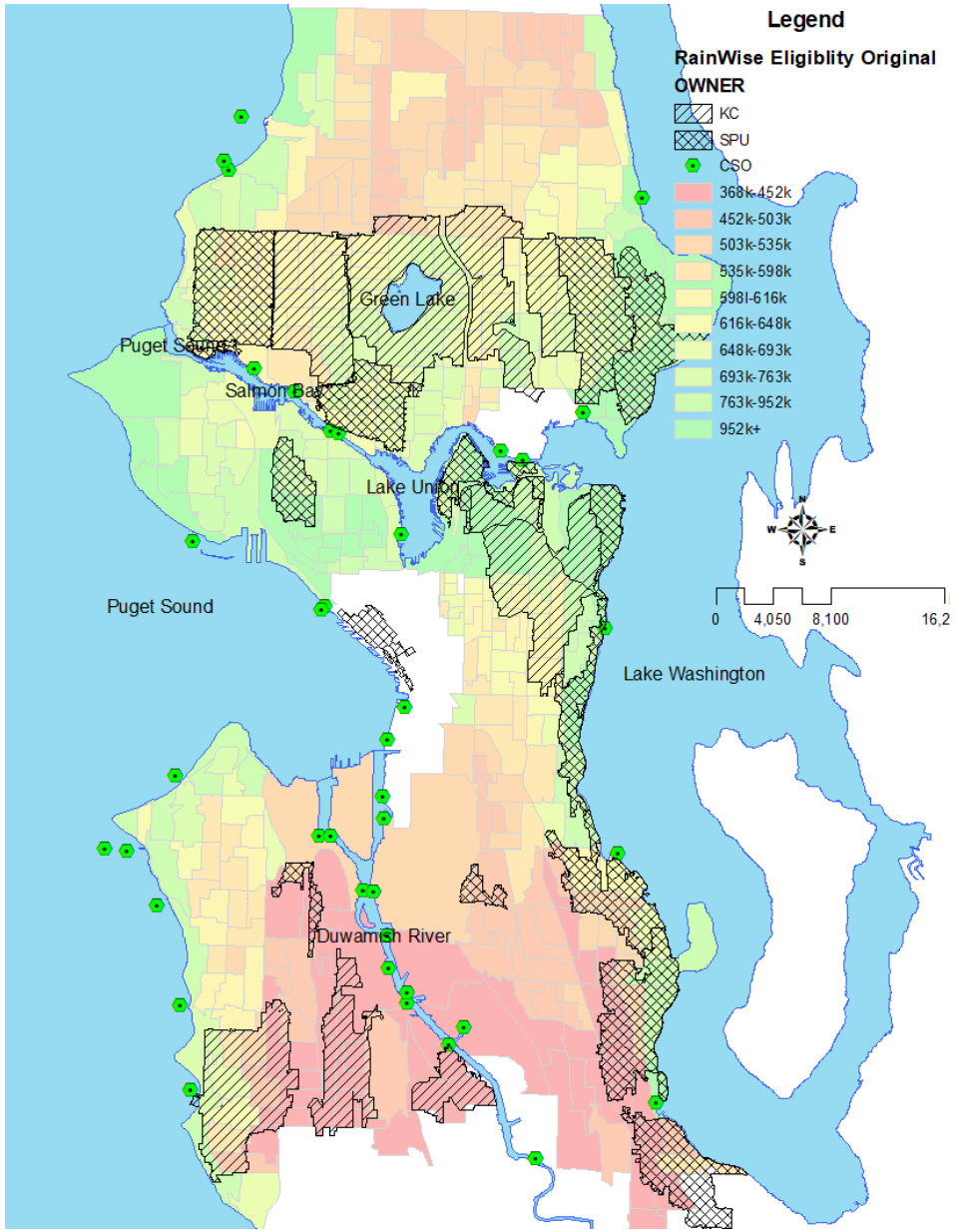
Data Sources

1. Public Data Request for all GSI data in shapefiles from Seattle
2. Assessor data on housing characteristics and housing sales
3. Census data on demographics at the block group level

Notes

- Both KC and Seattle fund RainWise
- Eligibility areas are based on sewersheds that feed to specific combined sewer outfalls
- These are all within the City of Seattle

Eligibility area



Summary statistics

Full Sample (predicted housing value)

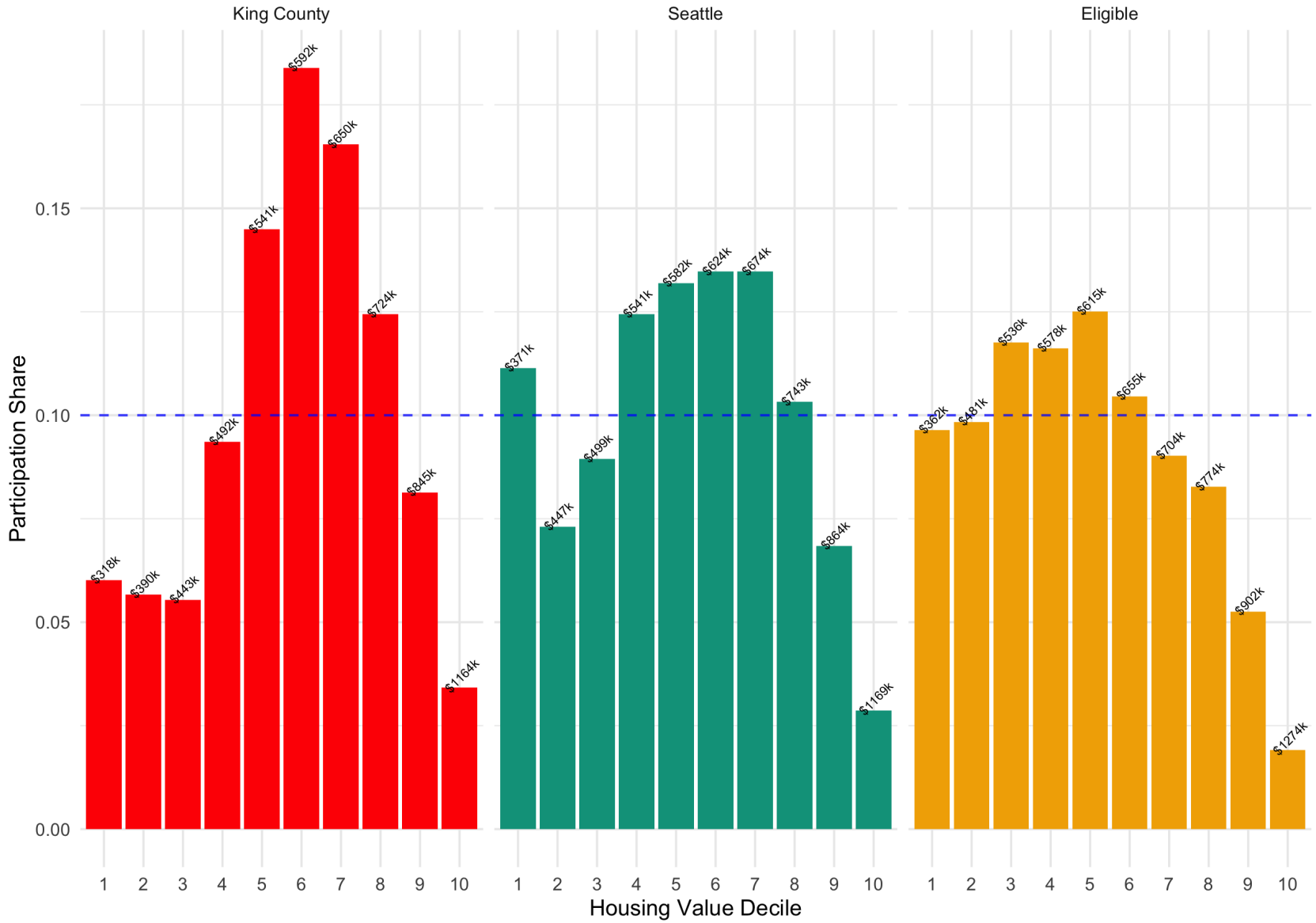
Variable	Mean KC	Mean Seattle	Mean RW Eligible	T-KC	T-SEA
House Value	624321	637740	704639	< 0.001	< 0.001
Med. Income	89454	78985	88810	0.793	0.001
Black	0.058	0.076	0.07	0.12	0.395
Tree Canopy		0.254	0.253		0.656
Lot	28090	6180	5190	< 0.001	< 0.001
Sq.ft.	2198	1833	1859	< 0.001	< 0.001
Year Built	1977	1953	1944	< 0.001	< 0.001
Degree	0.427	0.6	0.661	< 0.001	< 0.001
Observations	508684	156236	63806		

Summary statistics

Sales Sample (sale price)

Variable	Mean KC	Mean Seattle	Mean RW Eligible	T-KC	T-SEA
House Price	624693	663593	758955	< 0.001	< 0.001
Med. Income	102216	89495	100967	0.579	< 0.001
Black	0.065	0.091	0.075	0.062	0.022
Tree Canopy		0.261	0.256		0.586
Lot	18762	5190	4470	< 0.001	< 0.001
Sq.ft.	2361	1856	1910	< 0.001	< 0.001
Year Built	1984	1964	1955	< 0.001	< 0.001
Degree	0.486	0.665	0.757	< 0.001	< 0.001
Observations	184189	56206	22414		

Participation by housing value deciles



Empirical models

Two primary regression models

1. Participation model: probability of participating in RainWise in a given year
   - dependent variable = indicator for RainWise
2. Hedonic Selection model using housing sales **prior** to RainWise installation
   - dependent variable = sale price of house

Participation model

$$RW_{it} = \alpha + \theta_1 \widehat{HomeValue}_{it} + \theta_2 MedInc_{it} + \theta_3 Trees_i + \theta_4 Black_{it} + \boldsymbol{\beta X_{it}} + \epsilon_{it} \quad (1)$$

- RW_{it} dummy {0,1} for signing up for RainWise
- $MedInc_{it}$ median income at the block group level
- $Trees_{it}$ tree canopy at the block group level
- $Black_{it}$ % black at the block group level vector neighborhood variables (RainWise, public/private GSI, parks, trees)
- $\boldsymbol{X_{it}}$ vector of census and assessor characteristics, other GSI, and neighbor variables
- Sample restricted to **eligible households**

Participation model

We estimate the participation model using three different econometric models

1. Panel data logit model
2. Duration model
3. Linear probability model

Hedonic selection model

$$ln(P_{it}) = \alpha + \tau_t \delta_1 RW_{pre,it} + \delta_2 Sea_i + \delta_3 Eligible_i + \epsilon_{it} \quad (2)$$

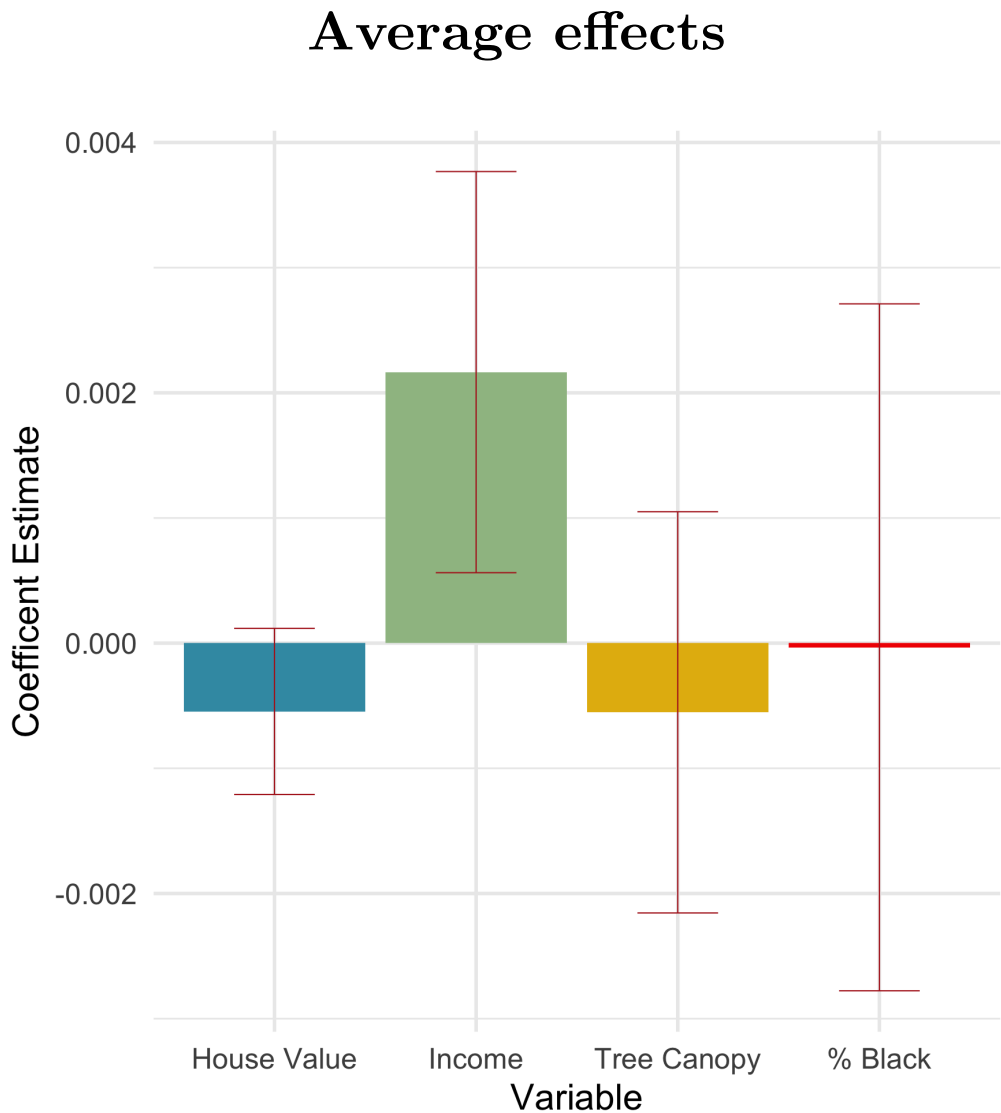
- P_{it} sale price (in Jan 2018 dollars)
- No controls except year-month FEs (τ_t) to capture selection
- RW_{it} dummy {0,1} for future RainWise participation (after the sale)
- Sea_i and $Basin_i$ are dummies for Seattle and eligibility basin

Hedonic selection model

We estimate the hedonic selection model using two different econometric models

1. OLS
2. Unconditional quantile regression

Participation model - logit marginal effects



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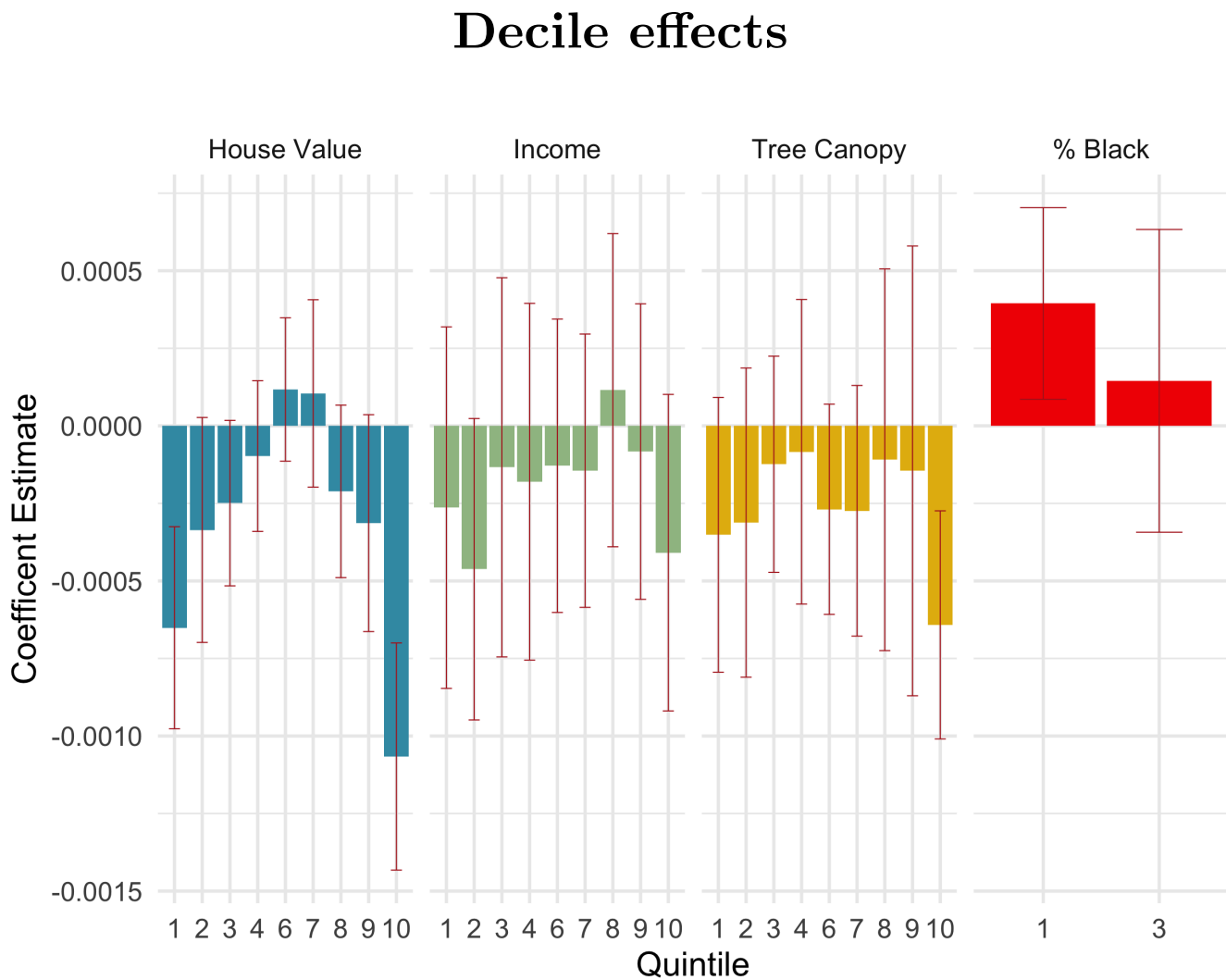


Selection Model

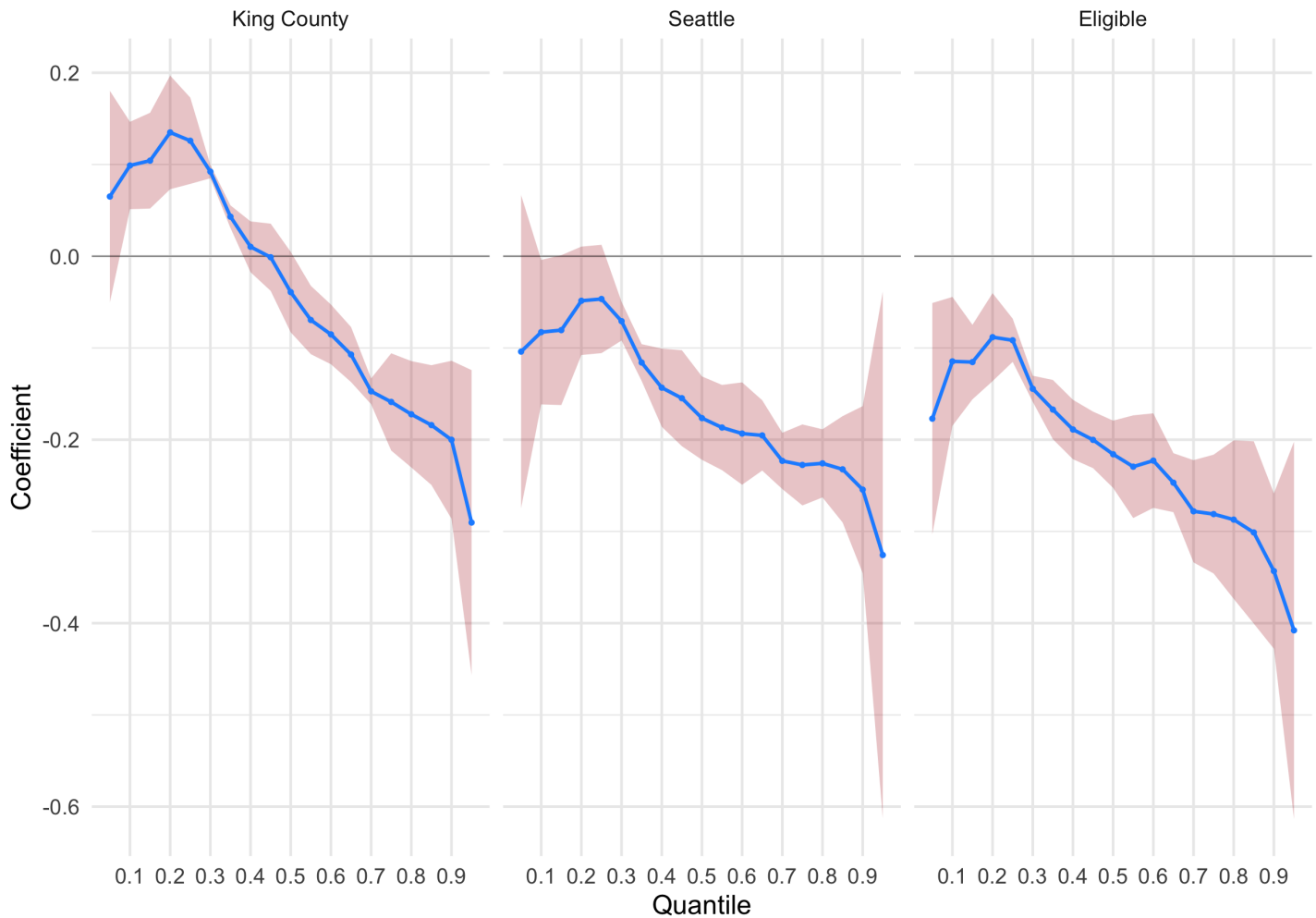
Rainwise participants ...

- are concentrated in the middle of the housing value distribution
- similar but more muted effects by income
- are more likely to live in predominantly white areas
- no effects of existing green infrastructure (tree canopy)
- have more RainWise neighbors (preliminary)

OLS

	King County	King County	King County	Eligible
	(1)	(2)	(3)	(4)
Rainwise	−0.032	−0.151***	−0.213***	−0.181***
	(0.023)	(0.023)	(0.023)	(0.057)
Seattle		0.173***	0.124***	
		(0.002)	(0.003)	
Eligible			0.126***	
			(0.004)	
Observations	180,334	180,334	180,334	21,890
R^2	0.072	0.097	0.102	0.132
Adjusted R^2	0.071	0.097	0.101	0.127

Quantile regression



Interpreting hedonic selection model

- Analyzing homes sold prior to signing up for RainWise (GSI not installed when sold)
- Eligible houses are a lot more expensive (especially compared to King County)
- Conditional on eligibility, houses that sign up are considerably less expensive
- The equity implications depend on eligibility considerations and spatial scope

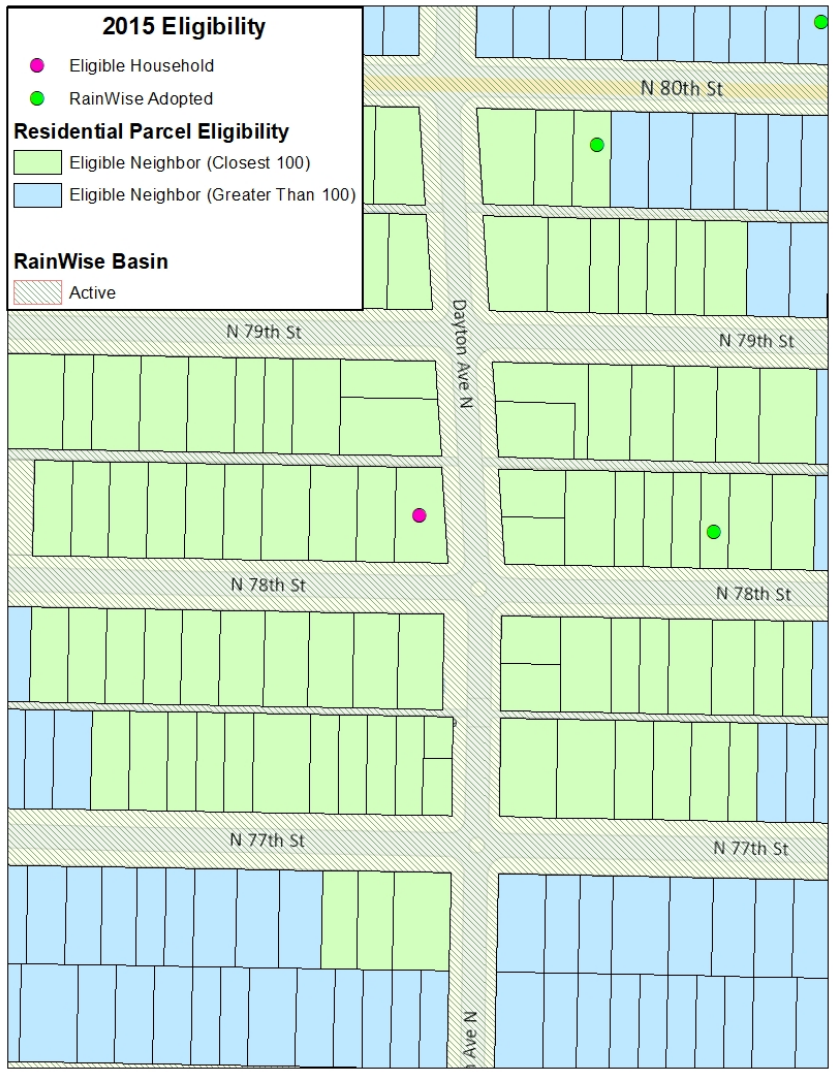
Capitalization effects

- Have done some work on capitalization
- Challenge is that not many homes have sold after adoption
- Matching and boundary discontinuity approaches show some capitalization effects and accounting for selection is important

Peer effects in adoption (WORK IN PROGRESS)

- Initial results showed strong peer effects
- These estimates are not casual
- New identification strategy to estimate causal effects exploits spatial and temporal variation in eligibility

Eligible Peers: Household 1



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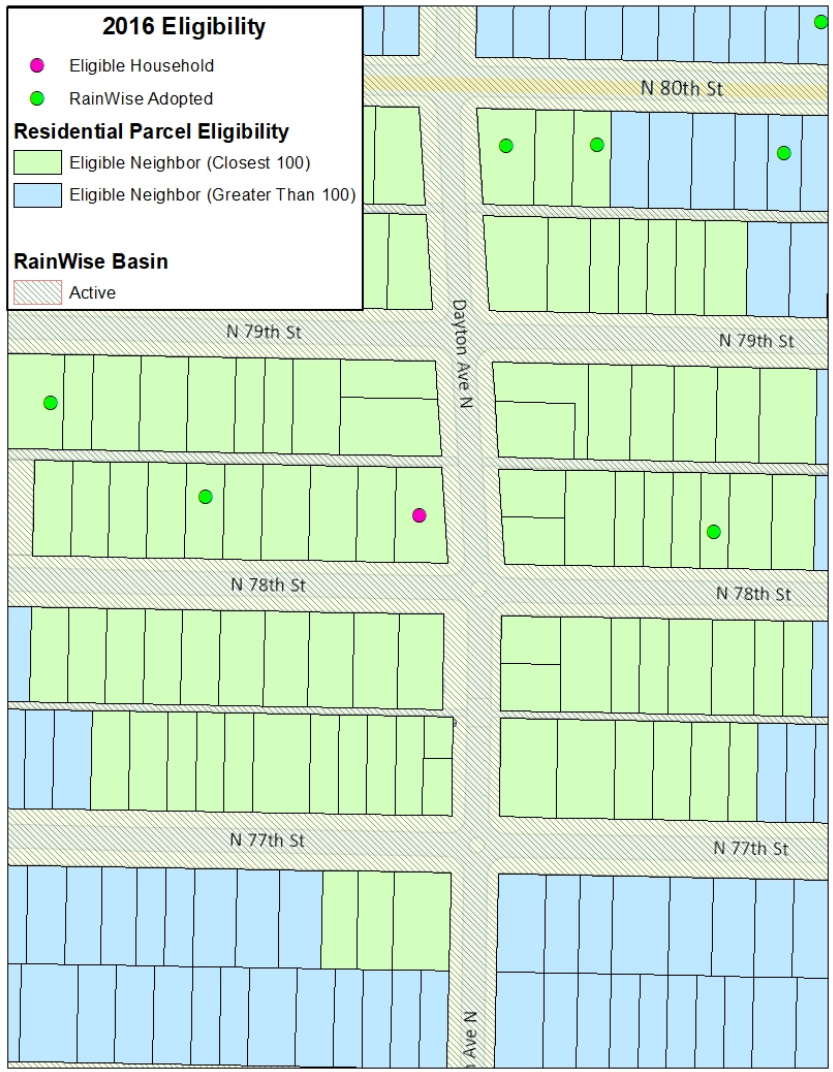

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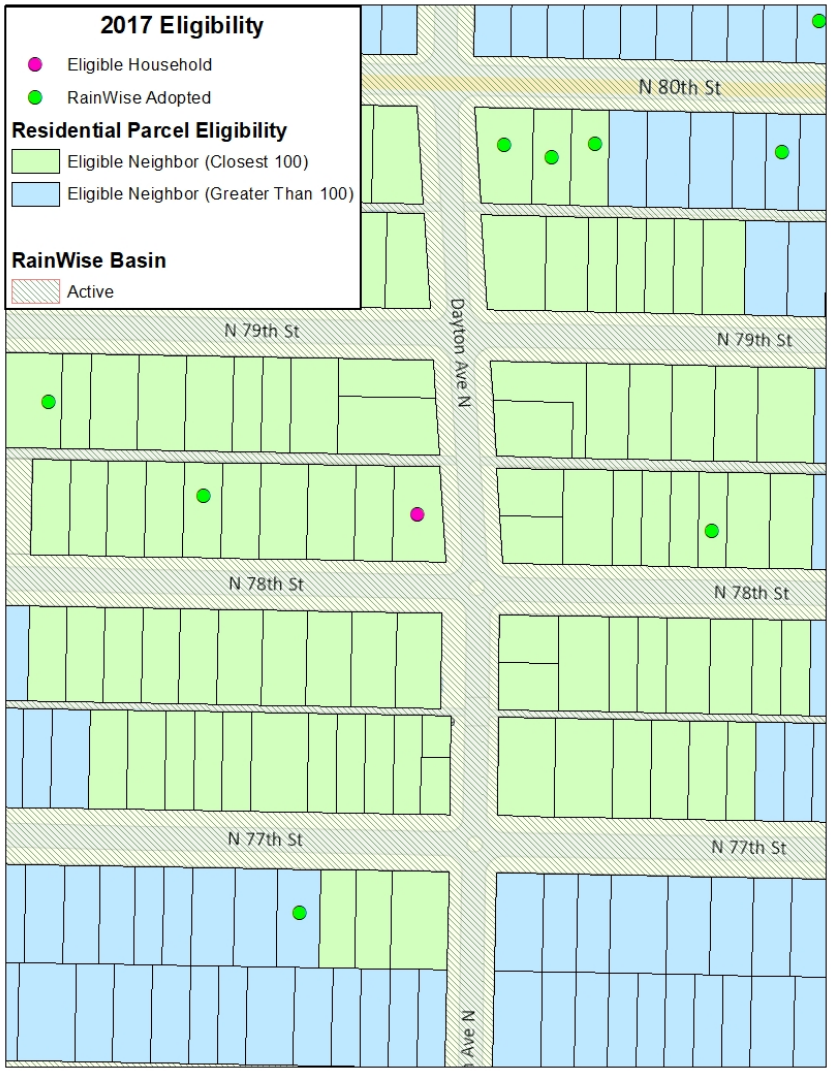

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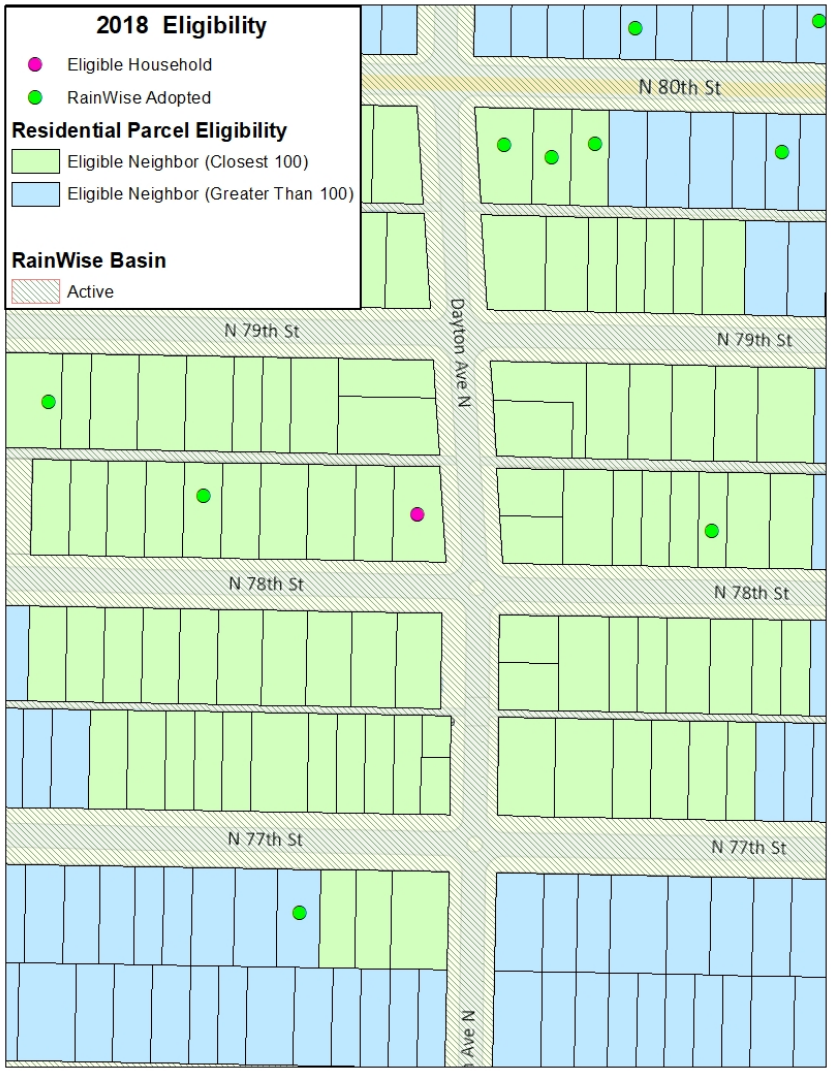
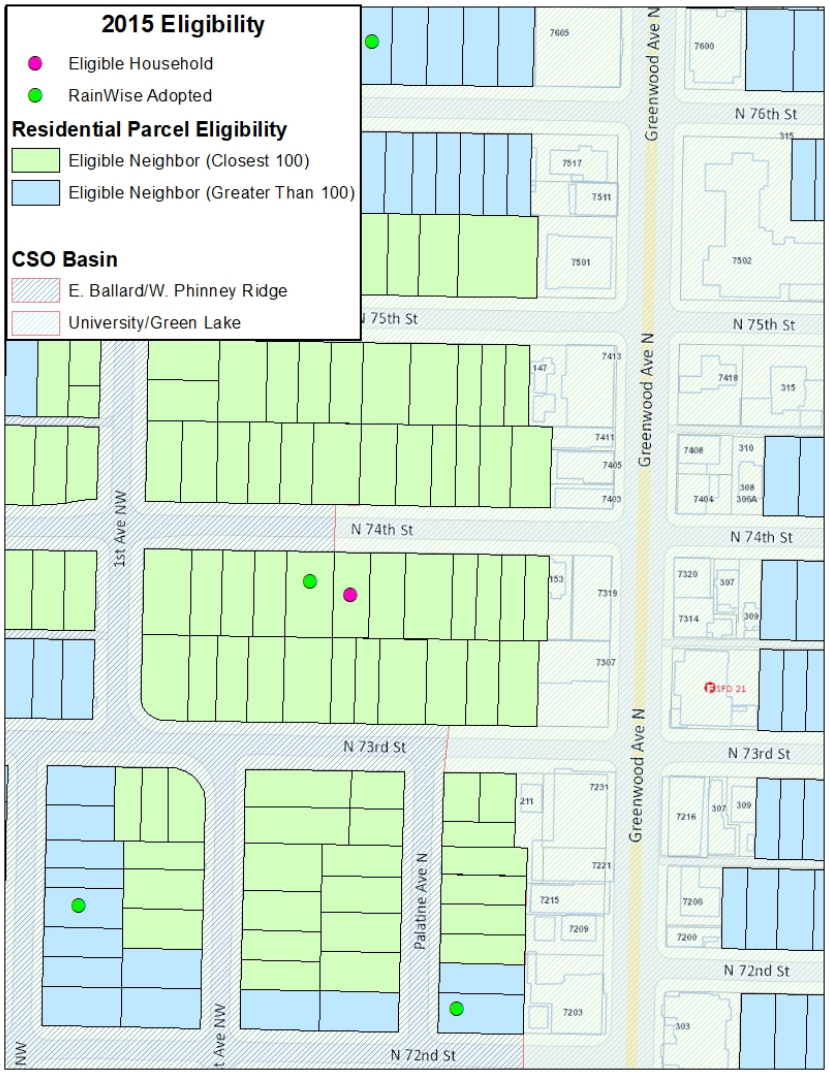


Eligible Peers: Household 2



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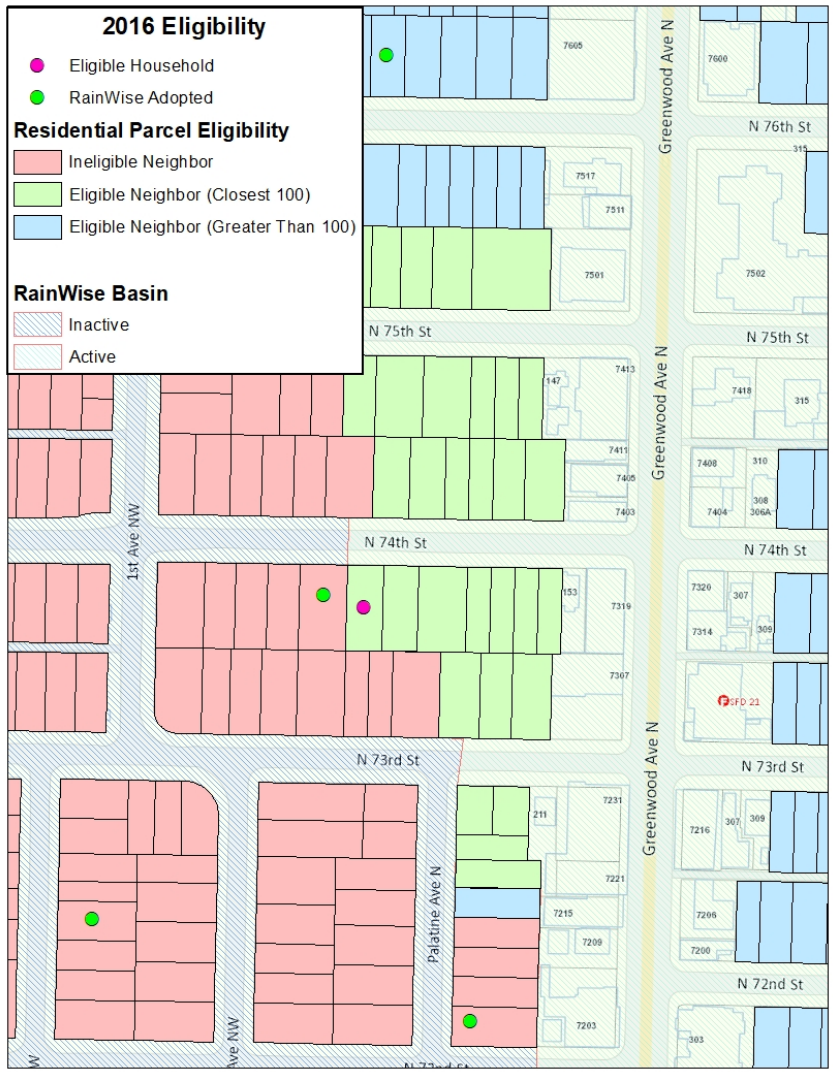

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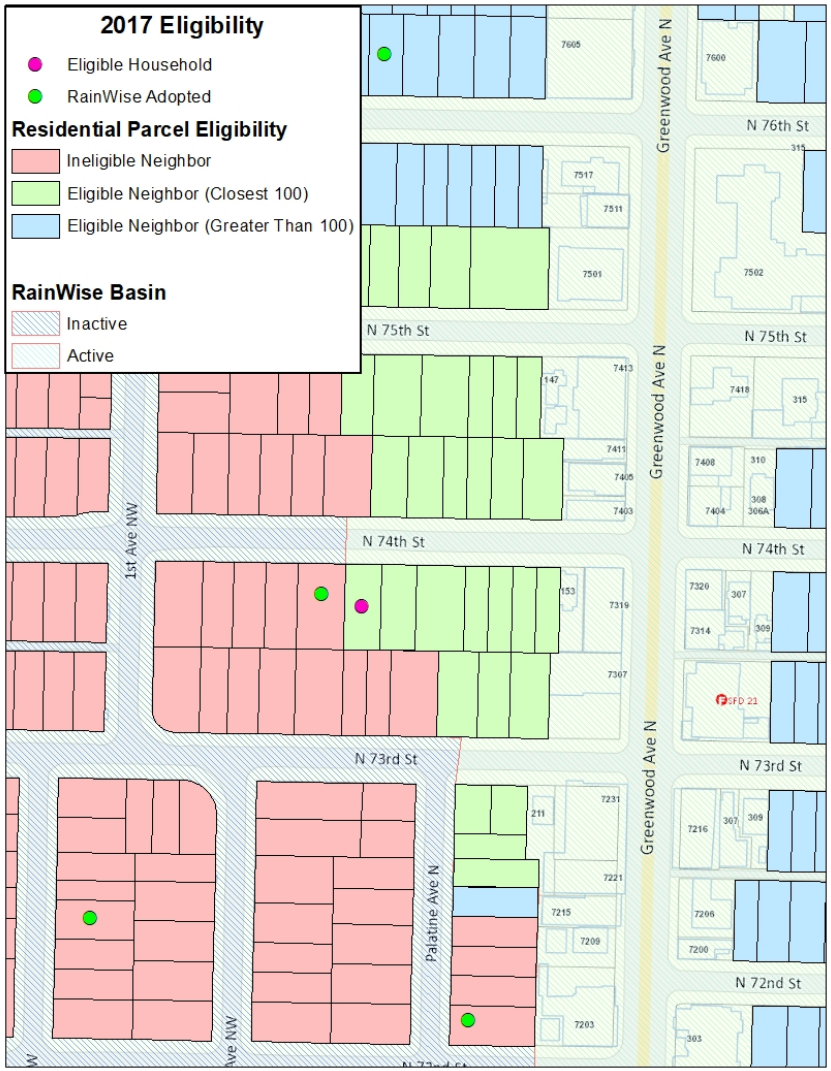

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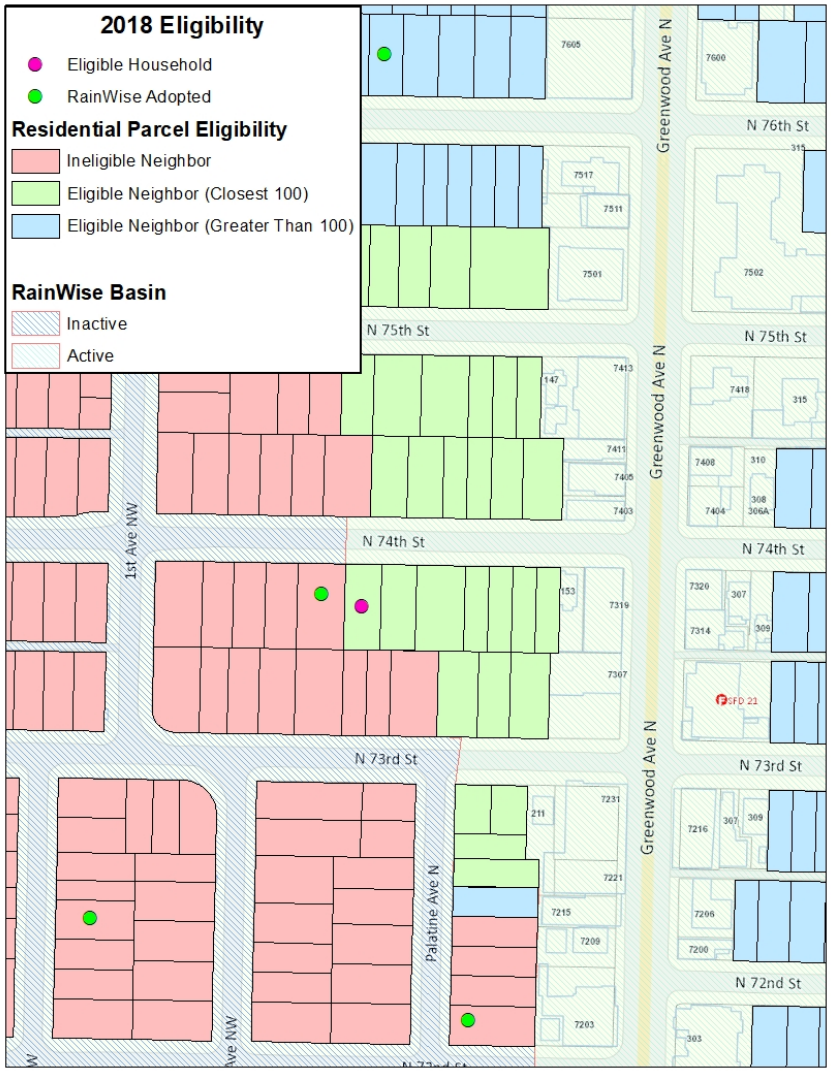

Distance from HH1 to HH2

Eligible Peers: Household 3

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Peer effects results

	OLS	First Stage	IV
	(1)	(2)	(3)
# Peers	0.001***		
	(0.0002)		
Eligible Peers		0.019***	
		(0.004)	
$\widehat{\#Peers}$			0.003***
			(0.001)
$E[Adopt_t]$	0.004		
Observations	449,534	449,534	449,534

Peer effects results

	0.1	0.2	0.3	0.4	0.5
	(1)	(2)	(3)	(4)	(5)
$\widehat{\#Peers}$	0.002***	0.003***	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	449,534	449,534	449,534	449,534	449,534

Outstanding questions/future work

- Is adoption the right measure for distributional effects?
  - ... maybe if there are capitalization effects
- Can we exploit our instrument to measure capitalization at different spatial scales?
  - Challenge: one instrument (eligible peers) two endogenous variables affecting capitalization (household adoption and neighbor adoption)
- What are the implications of voluntary adoption behavior and peer effects for balancing efficiency and equity goals?

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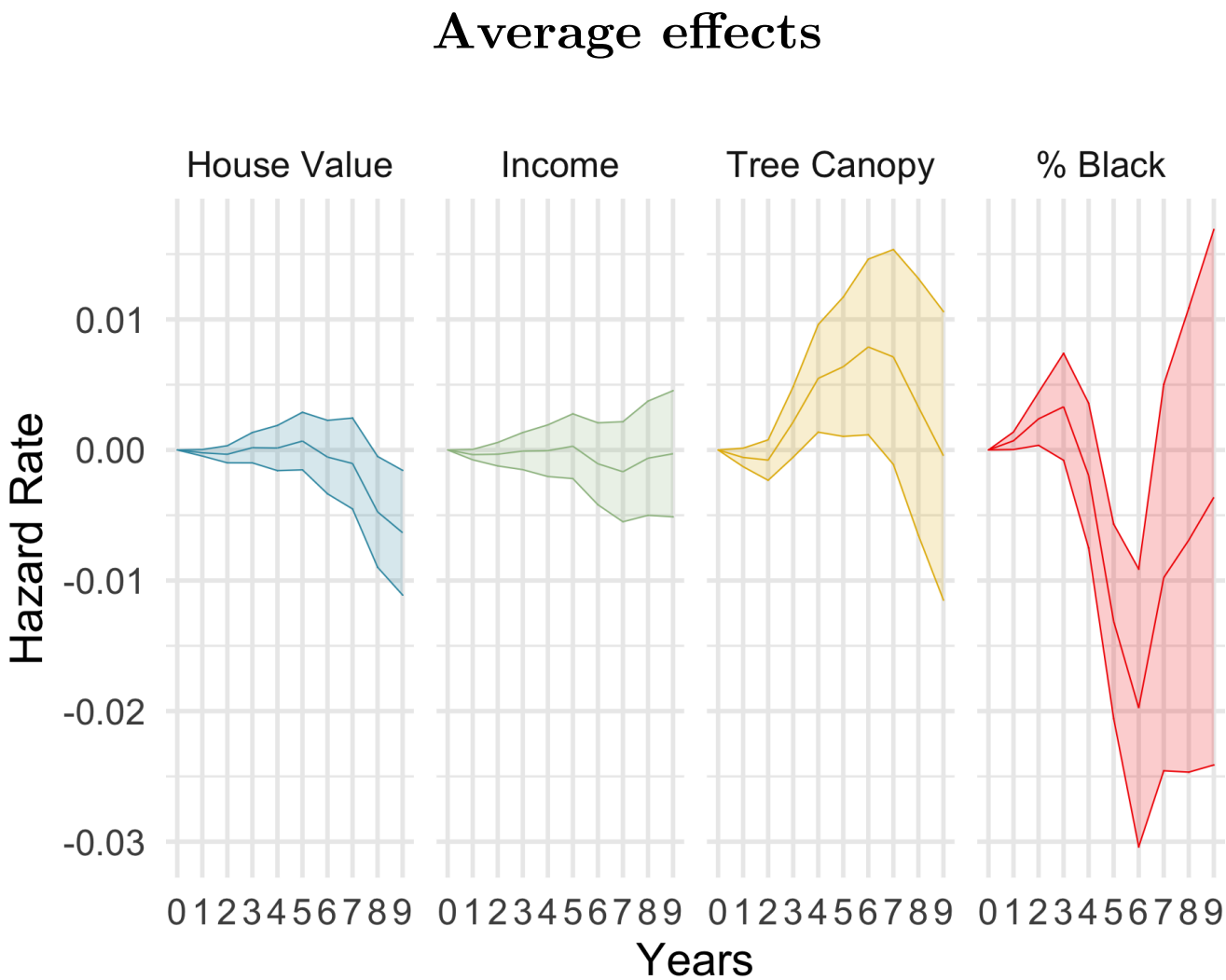
Extra Stuff

Participation model - hazard rates



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