Tightening the Belt:
The Impact of Greenbelts on Housing Affordability

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  - Policy that restricts development on undeveloped land
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- Concern over urban sprawl has prompted the creation of **Greenbelt** policies and urban growth boundaries
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  - Examples: Portland, London, Seoul, Toronto and more
- However, while greenbelts stop sprawl, they may ↑ housing costs

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  - Would allow for housing to be built more easily
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  - Would allow for housing to be built more easily
  - To some this extends to greenbelts too (see UK, Ontario)
- Contentious policy debate: housing affordability versus environmental protection
- Despite the intense debate, there is little empirical evidence on the impact of greenbelt policies on housing prices

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  - Housing Demand - Heritage designations IV
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  - Use transaction and development-level data aggregated to the census tract level
- **Policy Counterfactual:** Simulate housing market had Greenbelt not been implemented

Preview of Results

- By 2010, the Greenbelt ↑ avg. housing prices by 2.9% compared to a no greenbelt scenario
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- Why does the Greenbelt only account for a small share?
  - Reduction in Greenbelt *construction* ($\downarrow \sim 20\%$) only makes up 0.6% of total housing stock
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- Effect of Greenbelt can be entirely offset by moderate relaxation of zoning within city

Contribution to the Literature

- **Greenbelt & Anti-Sprawl Policies:** Koster (2023), Walsh (2007), Quigley & Swoboda (2007), Glaeser, Gyourko & Saks (2006), Bento et al. (2006), Anas & Rhee (2007), Brueckner (2007), Cunningham (2007), Deaton & Vyn (2010)
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  - My model studies short-run impact accounting for frictions and heterogeneity in housing supply

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- **Land Use Regulations:** Anagol et al. (2021), Kulka et al. (2023), Glaeser & Gyourko (2018), Cheshire et al. (2018), Hilber & Vermeulen (2016), Turner et al. (2014), Saiz (2010), Glaeser & Ward (2009), Ihlanfeldt (2007), Mayer & Somerville (2000)
  - Role of land use regulations on the urban fringe compared to within the city

Ontario Greenbelt

- The Greater Toronto Area saw a period of immense growth in the 2000s
  - Grew 16% between 2000 and 2010
  - For comparison, NYC grew 2.2%, LA 2.8%

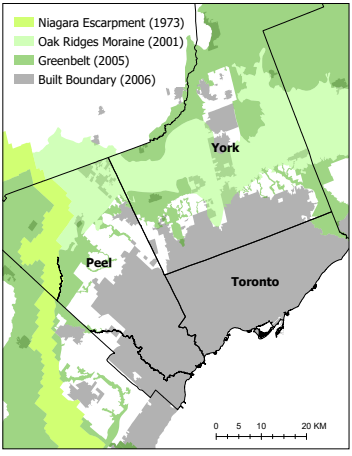


Figure: Ontario Greenbelt

Ontario Greenbelt

- The Greater Toronto Area saw a period of immense growth in the 2000s
  - Grew 16% between 2000 and 2010
  - For comparison, NYC grew 2.2%, LA 2.8%
- Opposition to urban sprawl led to the creation of
  - The Oak Ridges Moraine in late-2001
  - The Ontario Greenbelt in 2005
- Largest contiguous Greenbelt in the world (2M acres)
- Protects prime agricultural land, forest, wetlands and headwaters for the region from development

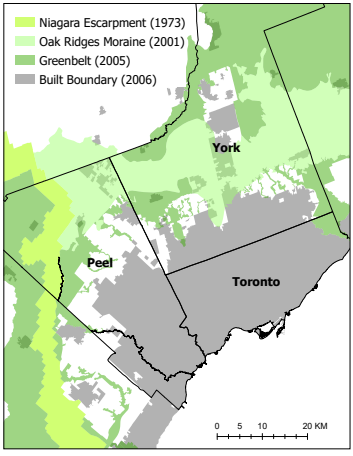


Figure: Ontario Greenbelt

Data Sources

- Teranet Housing Transactions Data (GeoWarehouse)
  - All transactions for Peel, York and Toronto from 2000-2010
- Teranet Parcel Data
  - Parcel data for all parcels in the Greater Toronto Area
  - Matched to transactions data through parcel PINs
- Altus - New Housing Construction Data
  - All housing development projects in the GTA since 2000
  - Includes info on number of units, date of first sale and closest intersection
- Public information on observable characteristics
  - Satellite imagery from Agriculture and Agri-food Canada (AAFC) (every 5 years since 2000)
  - Heritage designations and dates of designation from municipal sources

Summary Statistics

Motivating Evidence I

Starts Over Time

- Plot when projects started being sold by type of unit
- After the Greenbelt was introduced
  - ↓ in Single Family Homes
  - ↑ in Condominiums
- Suggests Greenbelt may have effect
  - ↓ sprawl & ↑ density
- Trend could occur for many reasons
  - Preferences? Building costs?

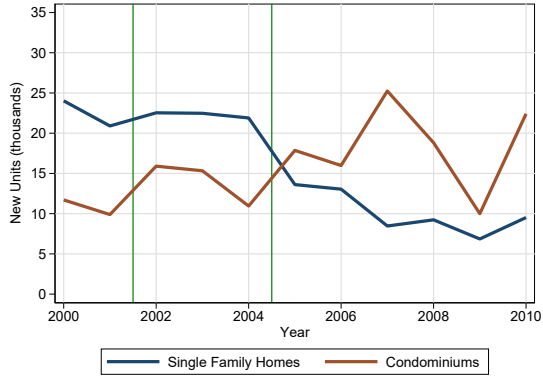


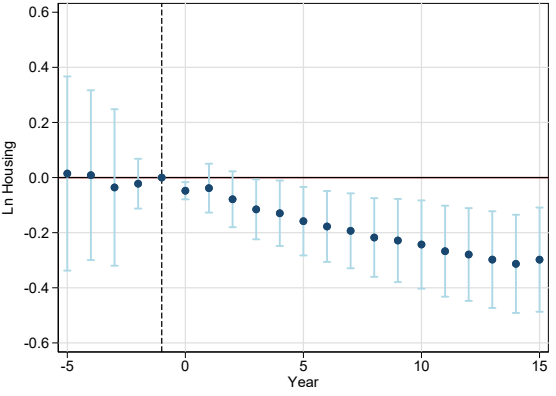
Figure: Total Units Brought to Market By Type, 2000-2010

Motivating Evidence II

Event Study

$$\ln H_{jt} = \sum_{g=-G}^{-2} \alpha^g D_{jt}^g + \sum_{k=0}^{K} \alpha^k D_{jt}^k + \nu_j + \eta_t + \varepsilon_{jt}$$

- D_{jt}^k: treatment indicator for Greenbelt status at a time gap, k, since treatment
  - Treatment: $>$ 50% of CT in GB
  - Sample: $>$ 25% of CT developable
- α^k: parameters of interest
- $\ln H_{jt}$: log of housing by CT, j, at time t
- ν_j & η_t: CT and Year FEs



Not Causal: Spillovers into control → Need model Figure: Housing in Restricted Tracts Versus Unrestricted

Details C&S ATTGT Partial Treated Continuous Treatment Variable Vary Greenbelt Threshold Vary Developable Land Threshold

Housing Supply

- A convex, constant elasticity cost function yields a supply curve for housing type i, in CT, j

$$H_{ijt}^{S}(P_{ijt}) = \eta_{ij} \left(P_{ijt}\right)^{\varphi_{ijt}}$$

- Writing as percentage changes over time and taking logs yields

$$\ln H_{ijt} = \ln H_{ijt-1} + \eta_{ij} + \varphi_{ijt} \left(\ln P_{ijt} - \ln P_{ijt-1}\right)$$

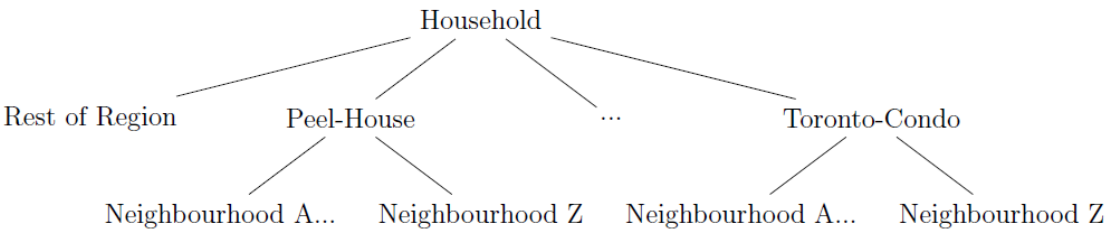
- φ_{ijt} - housing supply elasticity that varies across type, location and time
  - Specify as a linear function of tract-level characteristics: $\varphi_{ijt} = \gamma_0 + \gamma_1 x_{ijt}$
  - Can change as characteristics do (eg. loss of developable land/greenbelt)

- Imposing the condition that $H_{ijt} \geq H_{ijt-1}$ means that housing is an irreversible investment

Housing Demand

A Nested, Location Choice Framework

- Households choose where to live, first by choosing an upper-tier municipality (eg. Peel) and housing type (eg. condo) pair and then choosing a census tract within that nest
  - Generates more flexible substitution patterns than plain logit



Housing Demand

A Nested, Location Choice Framework

- Household utility can is then a function of location characteristics, where B signifies the nest

$$U_{ijt} = \underbrace{\alpha P_{ijt} + x_{ijt}\beta + \xi_{ijt}}_{\delta_{ijt}} + \bar{\epsilon}_{Bt} + (1-\rho)\bar{\epsilon_{ijt}}$$

- If the error term $\epsilon_{ijt} = \bar{\epsilon}_{Bt} + (1-\rho)\bar{\epsilon_{ijt}}$ is T1EV, the share in location j in housing type i is

$$s_{ijt} = \frac{\exp\left(\delta_{ijt}/(1-\rho)\right)}{\sum_{ij\in B}\exp\left(\delta_{ijt}/(1-\rho)\right)} \frac{\left(\sum_{ij\in B}\exp\left(\delta_{ijt}/(1-\rho)\right)\right)^{(1-\rho)}}{1+\sum_{h}\exp\left(\delta_{ht}\right)}$$

- Multiplying the shares by market size, M_t, yields the housing demand curve, $H^D_{ijt}(P_{ijt})$

Supply Curve Estimation

$$\Delta \ln H_{ijt} = \tilde{\eta_{ij}} + (\gamma_0 + \gamma_1 x_{ij})\Delta \ln P_{ijt} + \varepsilon_{ijt}$$

- $\Delta \ln H_{ijt}$ - Δ in the housing stock supplied at time t
- $\Delta \ln P_{ijt}$ - Δ in the price index at time t
- x_{ij} - observable characteristics of housing type i in census tract j
  - % of developable land, unit type (Condo, Urban, Suburban), in an "urban growth center" Map
  - γ_0, γ_1 - parameters of interest

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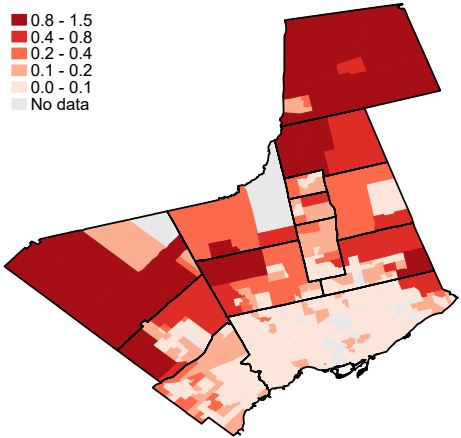
Challenge: The change in price is an endogenous/simultaneously determined variable

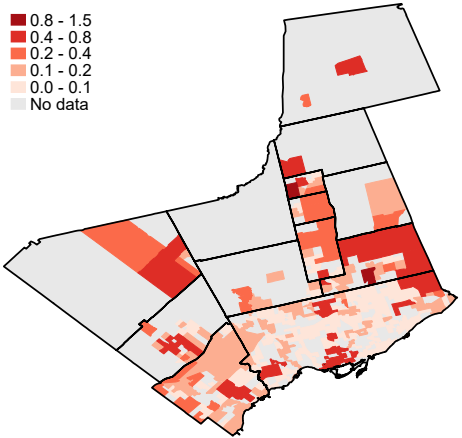
- Use the Simulated $\Delta \ln$ Residential Market Access (RMA) (Han & Baum-Snow, 2023)
- Idea: Exogenous shocks to labour demand in one location shocks housing demand in nearby areas
- Use Bartik-shifts in aggregate labour demand to isolate exogenous shocks to labour demand

Simulated RMA in 2010 Year-to-Year Variation

Predicted Supply Elasticities Across Space



(a) Single Family Homes



(b) Condominiums

Table of Coefficients

Housing Demand

- Dividing by the outside option and taking logs of the housing demand curve, $H^D_{ijt}(P_{ijt})$

$$\ln s_{ijt} - \ln s_0 = \alpha P_{ijt} + x_{ijt}\beta + \xi_{ijt} + \rho \ln s_{ijt|Bt}$$

- s_{ijt} - the share of housing type i in census tract j of all housing
- s_0 - the share of population living in the outside option (regions surrounding GTA)
- $x_{ijt}\beta + \xi_{ijt}$ - Captured by observable characteristics and unit FEs
  - Sociodemographic characteristics of neighbourhood (education, income)
  - Housing characteristics (age of housing stock, lot size, footprint, distance to CBD)
- $s_{ijt|Bt}$ - the within-nest share of a location and unit type

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Challenge: The change in price is again an endogenous/simultaneously determined variable

- Use a heritage designations instrument $\rightarrow \uparrow$ designations $= \downarrow$ supply shifter
- Idea: Once designated a building cannot be redeveloped without significant difficulty + correlated with active neighbours

Measuring Heritage

- Collect data on all designated heritage properties and the date of listing for the GTA
- Calculate Heritage exposure as the # of properties within 10 km
  - Discounted by distance using a weight of $\frac{1}{km^2}$
- Significant variation in heritage listings across the region
  - Not strictly correlated with distance to CBD
  - Interact instrument with unit type to vary by type
- $\uparrow$ distance-discounted designations within 10 km $\rightarrow \uparrow$ more community coordination & $\downarrow$ land available for development

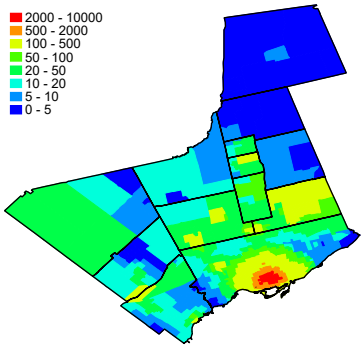


Figure: Heritage Designations, 2010

Designations Over Time

Housing Demand Curve Results

	OLS		IV - By Radius			IV - With Lags	
	10km	10km	5km	10km	15km	Lag 1-Yr	Lag 2-Yr
Prices (in $10,000)	0.0083***	0.0035**	-0.0376***	-0.0395***	-0.0390***	-0.0385***	-0.0369***
	(0.0017)	(0.0014)	(0.0035)	(0.0038)	(0.0037)	(0.0038)	(0.0036)
ρ			0.2301***	0.2341***	0.2328***	0.2424***	0.2515***
			(0.0289)	(0.0299)	(0.0297)	(0.0316)	(0.0328)
Controls	X	✓	✓	✓	✓	✓	✓
Unit FE	X	✓	✓	✓	✓	✓	✓
Year	X	✓	✓	✓	✓	✓	✓
N	11910	11910	11910	11910	11910	10719	9528
Kleibergen-Paap F			34.08	35	34.03	28.84	29.08
Hansen-J			.9193	.9753	.8314	.9994	.9873

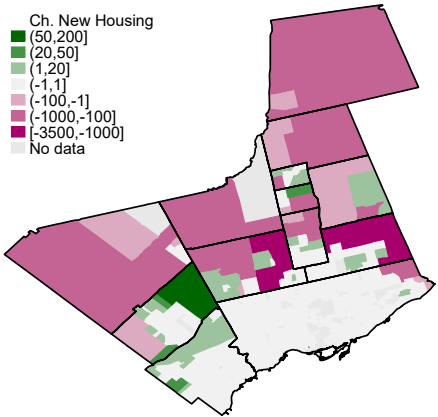
Standard Errors are Clustered at the CSD x Unit Type x Year level

- IV with 10 km radius generates an average elasticity of -1.68
- $\rho = 0.23$ suggests that households are only moderately attached to their nest

Counterfactual: No Greenbelt

- Counterfactual without greenbelt is done by shifting the share of developable land in $\varphi_{ijt} = \gamma_0 + \gamma_1 x_{ijt}$
- Simulating the model with more elastic supply curves, I find that...
  1. Average prices $\uparrow$ 2.9% by 2010 due to the Greenbelt
     - With a price-to-rent ratio of 20 for Toronto, this amounts to an $\uparrow$ of \$600 a year in rent
     - Explains only 4% of the overall $\uparrow$ in prices during this period
  2. Total construction $\downarrow$ by 13-14k units within the Greenbelt and $\uparrow$ by 2k units outside
     - $\downarrow$ construction in Greenbelt areas by 20% on average
     - $\downarrow$ the total housing stock in the GTA by 0.6%

No Greenbelt: Δ Housing Construction Across Space



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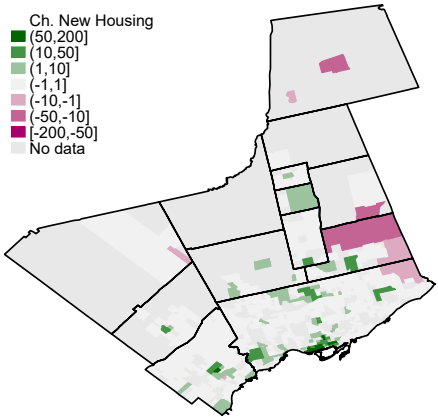
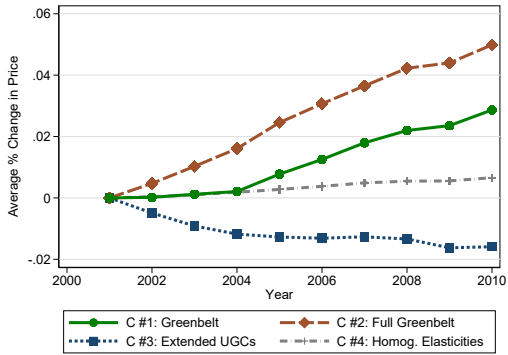


(b) Condominiums

Other Counterfactuals

- C#2: Does a completely restrictive Greenbelt in 2002 have a larger effect?
  - Only slightly, price ↑ 5%
- C#3: Does relaxing zoning restrictions within city mitigate effects?
  - Yes, prices fall when Greenbelt paired with zoning deregulation within the city
- C#4: Do hetero. supply elasticities matter?
  - Yes, effects are three times larger when accounting for heterogeneity
  - Pushing demand onto less elastic locations



Thank You!

Questions or Comments?
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Summary Statistics

At the Census Tract Level in 2010

	Mean	Min	Median	Max
Condominiums				
# Units	1,175	5	797	14,042
Δ # Units 2001-2010	303	0	0	12,242
Sale Price ($)	285,865	63,642	265,275	1,039,340
Δ Sale Price 2001-2010 (%)	56	-47	50	452
Distance to CBD (km)	17	0	17	74
Census Tract Size (acres)	554	13	202	22,962
Undeveloped Land %	4	0	0	90
Greenbelt %	1	0	0	71
Single Family Homes				
# Units	1,437	120	1,185	18,472
Δ # Units 2001-2010	237	0	0	15,048
Sale Price ($)	498,464	213,926	458,921	1,177,189
Δ Sale Price 2001-2010 (%)	78	5	74	528
Distance to CBD (km)	18	1	17	82
Census Tract Size (acres)	992	30	218	40,857
Undeveloped Land %	6	0	0	94
Greenbelt %	2	0	0	92

- 714 census tracts with single family homes and 477 census tracts with condominiums

Return

Details of Event Study

- Can compare trajectories of housing development of census tracts inside the Greenbelt to those just outside
  - Units: Single Family Homes
  - Treatment: discrete, $>$ 50% Greenbelt coverage
  - Control: $>$ 25% developable land share in a CT
  - Timing: 2 phases - late-2001 and 2005
- Presence of spillovers means this is only a *relative effect*
  - Greenbelt may push development into control group
  - Magnitude of estimate is not interpretable

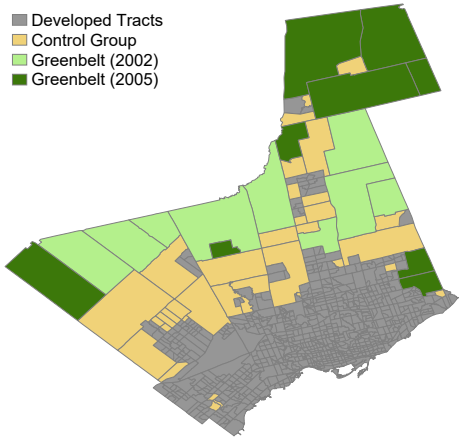


Figure: Ontario Greenbelt

Return

Callaway & Sant'Anna (2021) ATTGT's

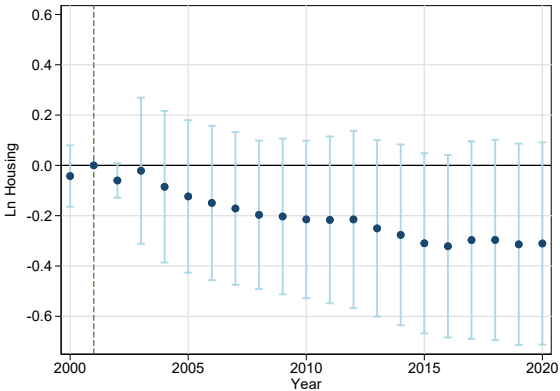


Figure: Treated in 2001

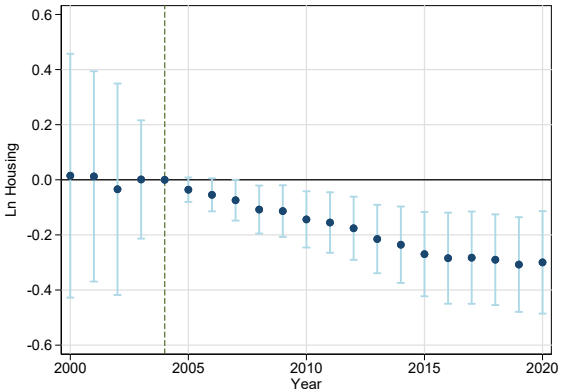


Figure: Treated in 2005

Return

Continuous TWFE Results

	Undeveloped Land Share				
	20%	25%	30%	35%	40%
Continuous Treatment	-0.16404	-0.17740	-0.27921**	-0.34771**	-0.39829***
	(0.11591)	(0.11655)	(0.12362)	(0.13241)	(0.13899)
N	1617	1365	1197	1071	987
R^2	0.938	0.940	0.938	0.934	0.931

Standard errors in parentheses

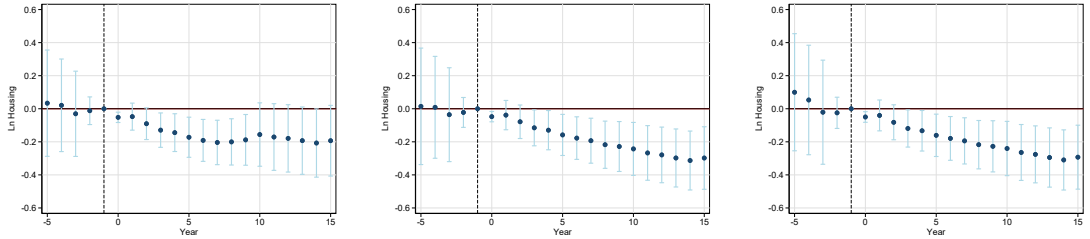
Standard Errors Clustered at the Census Tract Level

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

- Greenbelt lowers housing levels in treated areas by 1.5-4% for every 10% of Greenbelt coverage
- Effect grows when comparing to less developed census tracts
- Standard errors clustered at the census tract level

Return

Vary Greenbelt Threshold

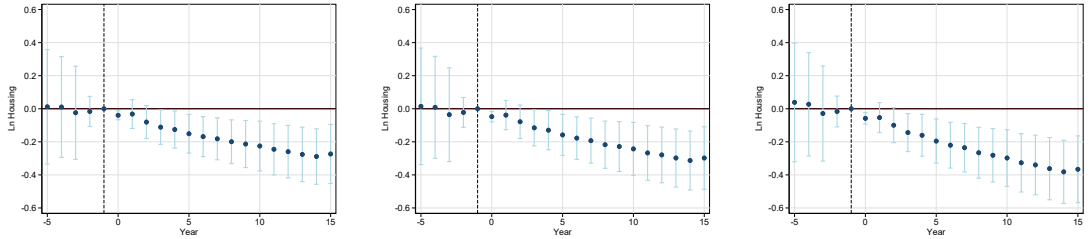


(a) GB Threshold: 45% (b) GB Threshold: 50% (main) (c) GB Threshold: 55%

Figure: TWFE OLS Results by Greenbelt Threshold

Return

Vary Developable Land Threshold

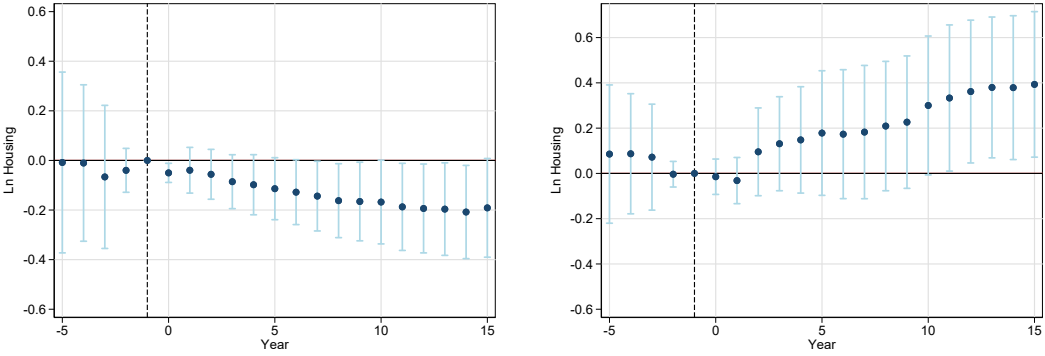


(a) Dev Threshold: 20% (b) Dev Threshold: 25% (main) (c) Dev Threshold: 30%

Figure: TWFE OLS Results by Greenbelt Threshold

Return

Housing Development by Greenbelt Group



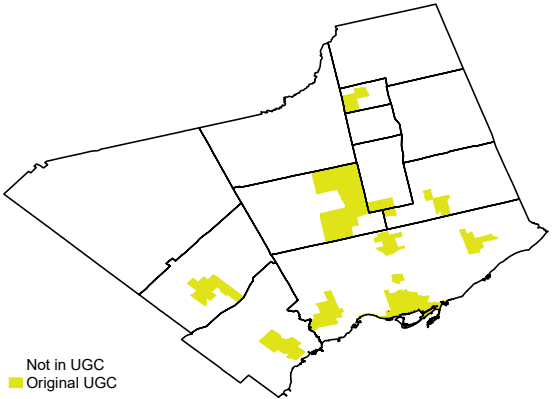
(a) Greenbelt % $>$ 50%

(b) 10% $<$ Greenbelt % $<$ 50%

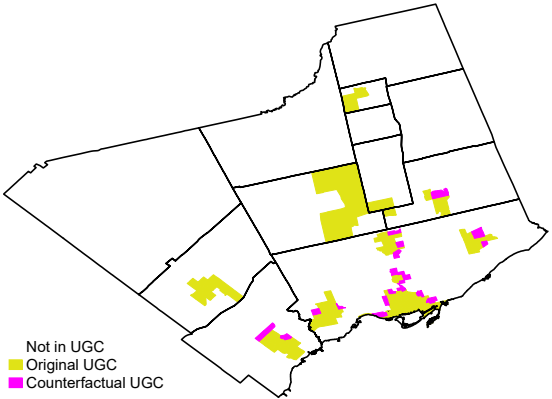
Figure: Treated Tracts versus Partially Treated Greenbelt Tracts

Return

Urban Growth Centers



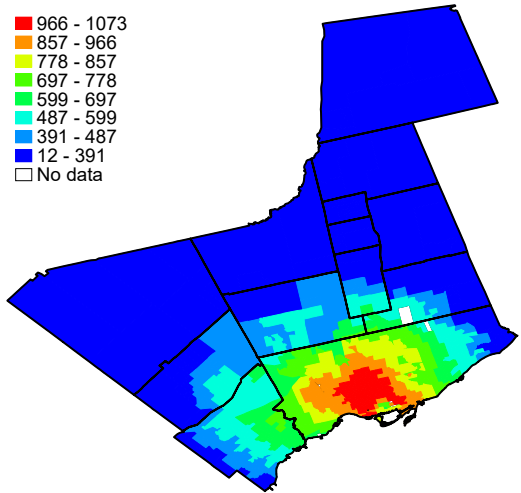
(a) Actual UGCs



(b) Proposed UGC Expansion

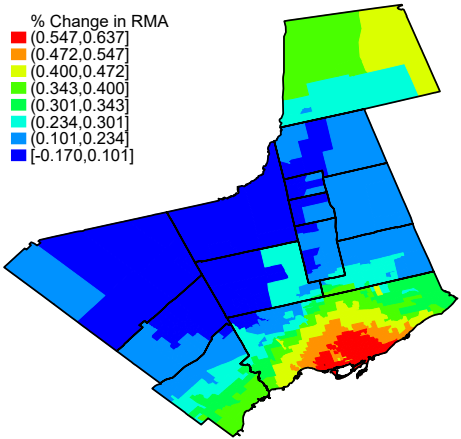
Return

Simulated RMA in 2010

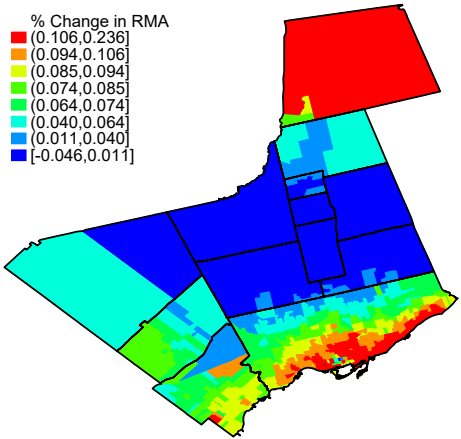


Return

Variation in Δ Simulated ln RMA Across Space



(a) 03-04



(b) 09-10

Return

Heterogeneous Supply Elasticity Regression

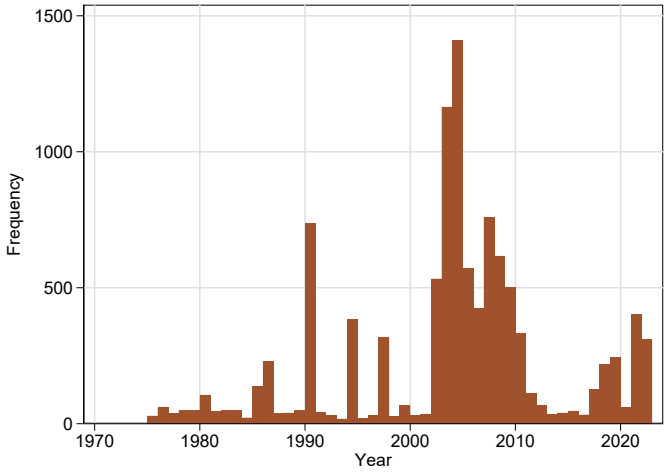
Estimates of γ_0 and γ_1

	No Controls		With Control Vars		CT FEs	
	IV	IV	OLS	IV	OLS	IV
Baseline = Urban House						
$\Delta \ln P$ - Pre-2005	0.078***	0.034	-0.021	0.048	0.014	0.155**
	(0.023)	(0.038)	(0.014)	(0.039)	(0.012)	(0.073)
Post – 2005	-0.050	-0.056*	-0.021	-0.058*	-0.031**	-0.051
	(0.031)	(0.032)	(0.016)	(0.032)	(0.015)	(0.038)
Suburban House (> 25% Dev Land)						
$\Delta \ln P$	-0.094	-0.074	0.027	-0.139	-0.015	-0.309
	(0.132)	(0.132)	(0.083)	(0.148)	(0.097)	(0.207)
$\Delta \ln P$ x % Dev Land	1.291***	1.267***	0.444	1.176***	0.225	0.804
	(0.399)	(0.399)	(0.280)	(0.400)	(0.349)	(0.591)
Condominium						
$\Delta \ln P$	0.146***	0.124**	0.025*	0.033	0.013	-0.060
	(0.051)	(0.058)	(0.014)	(0.096)	(0.013)	(0.306)
$\Delta \ln P$ x % Dev Land	0.696	0.748	0.107	0.586	0.079	0.571
	(0.575)	(0.563)	(0.144)	(0.665)	(0.139)	(0.951)
$\Delta \ln P$ x UGC = 1	0.587***	0.607***	0.096**	0.613***	-0.013	0.645
	(0.162)	(0.159)	(0.045)	(0.162)	(0.043)	(0.430)
Constant		0.004	0.191***	0.129*		
		(0.003)	(0.037)	(0.072)		
Controls	X	X	✓	✓	X	X
CT x Unit FE	X	X	X	X	✓	✓
N	10719	10719	10719	10719	10719	10719
Kleibergen-Paap F	37.489	12.372		6.601		1.055
Mean ϕ (Pre-2005)	0.228	0.177	0.014	0.145	0.027	0.202
Mean ϕ (Post-2005)	0.161	0.104	-0.012	0.071	-0.007	0.140

Standard Errors are Clustered at the CT x Unit Type level

Return

Heritage Designations Over Time



Return