Land and the Rise in the Dispersion of House Prices and Rents across U.S. Cities

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Motivation: Shelter Cost

- Shelter cost is a major part of household expenditure
- Understanding why it varies across cities is important for evaluating households' welfare (Moretti, 2013; Albouy 2008)
- Measuring shelter costs: prices & rents
- Distributions of prices and rents across cities differ in levels and change in different magnitudes
- Understanding this difference is important for ownership decisions and life quality at different places

This Paper

- Document three stylized facts about joint distribution of prices and rents across cities
- Propose a mechanism that can quantitatively account for these facts

Distribution of Shelter Costs across U.S. Cities

1. Substantial variation in prices and rents across cities; Prices are more dispersed
   - CV of prices is 80% higher compared to rents in 1980
2. Dispersions of prices and rents grow at diffferent rates: 1980-2010
   - CV of prices almost doubled
   - CV of rents increased by 50%
3. High correlation between prices and rents across cities: cities with higher rents have even higher prices

2010	New York	Kansas City
Price	510,000	130,000
Rent	13,000	8,000

Motivation

Commonly used prices and rents capture cost of different types of dwellings

- $>$ 70% Renters live in apartments
  - Less land intensive

- $>$ 80% Owners live in detached houses
  - More land intensive
  - Subject to minimum lot zoning

Data Issue

Mechanism

- Houses and apartments differ in use of land
  - Houses take more land than apartments
- Land prices vary across cities
  - Davis and Palumbo, 2008; Albouy 2017
- In cities where land prices are high
  - Apartments economize on land by building up
  - Land use for houses is hard to adjust: nature & regulation
  - Cost of building houses disproportionally higher compared to apartments due to intensive use of land

Quantitatively Evaluate Mechanism

- Develop a city-level life-cycle housing tenure choice model
- Standard demand side: Finitely-lived households choose between buying a house and renting an apartment and the size to buy/rent based on age, income and wealth
- Supply side: Two production functions with same inputs but **different land shares**
- Mechanism
  - Same Inputs $\rightarrow$ high correlation between prices and rents
  - Different land shares $\rightarrow$ prices more dispersed compared to rents when land values vary across cities

Quantitatively Evaluate Mechanism

- Calibrate model to each of largest 181 metropolitan areas in 1980
  1. house prices
  2. rents
  3. fraction of households living in detached/attached house
- Perfectly match distributions of prices and rents in 1980 → Possible to produce changes in distributions overtime?
- Quantitative experiment: Feed in model factors that affect land market
  - Economic fundamentals: population and income
  - Residential land supply
  - Lower downpayment from 20% to 10%

What I Find

- Changes in population, income, residential land supply and downpayment requirement between 1980 and 2010 can account for
  - 82% of increase in dispersion of house prices
  - 56% of increase in dispersion of rents
  - 90% of increase in dispersion of price-rent ratios
    - Increasing price-rent ratio in some cities can be accounted for by economic fundamentals
    - Challenge view: price-rent ratio can be used as a convenient indicator for housing bubble
- Predict prices, rents and price-rent ratios for each individual city well in 2010.

Literature & Contribution

- Understanding cross-city variation in levels and growth rates of price-rent ratios: Allow price-rent ratios to vary with land values.
    - Kishor and Monrley (2015), Campbell et al. (2009), Case and Shiller (1989)
- Change in cross-city variation in prices: Extend analysis to changes in dispersion of rents or price-rent ratios.
    - Gyourko, Mayer and Sinai (2013) and van Nieuwerburgh and Weill (2010)
- Estimating production function of houses: Extend analysis to multi-family buildings.
    - Albouy (2018), Epple et al. (2010)
- Importance of residential land value on house price dynamics: How land values determined by fundamentals.
    - Davis and Oliner (2017), Davis and Palumbo (2008), Davis and Heathcote (2007)

Road Map

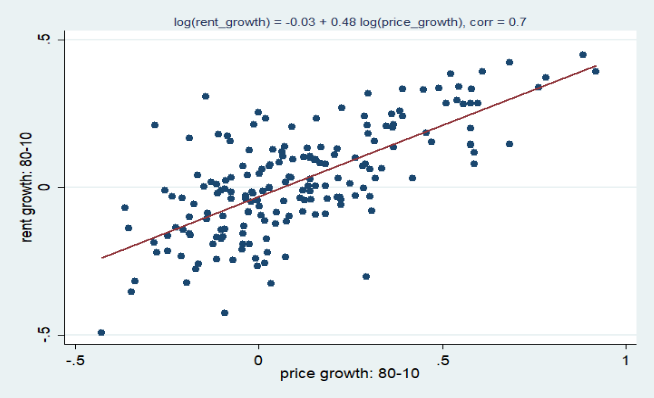
- Empirical Evidence
- Model
- Calibration
- Quantitative Exercise
- Conclusion

Empirical Evidence: Correlation between Prices and Rents

- House prices and apartment rents are highly correlated in
  - Level

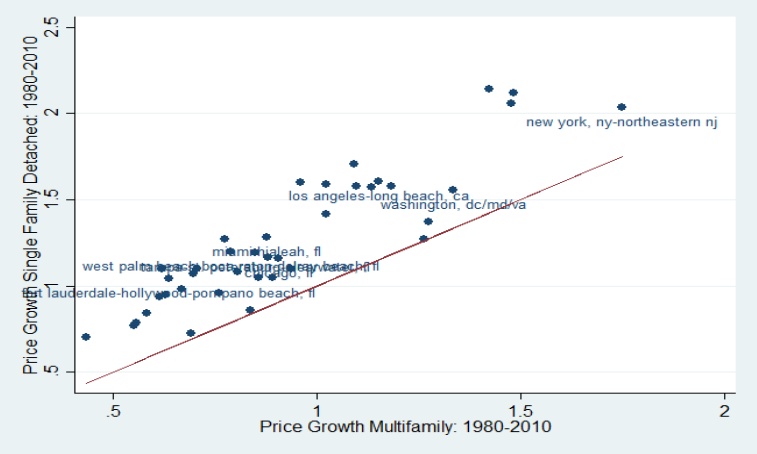
1980	0.73
2010	0.90

  - Growth rates



Motivation: Price Growth by Type

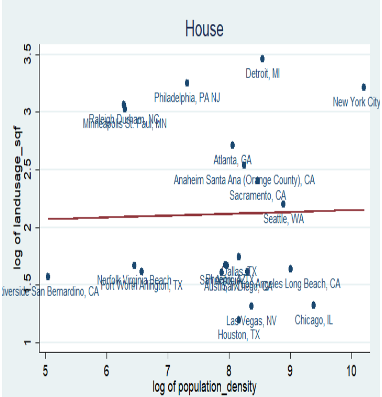
Price growth for Single Family Detached House larger than Multifamily Apartments (Built between 1950-1980)

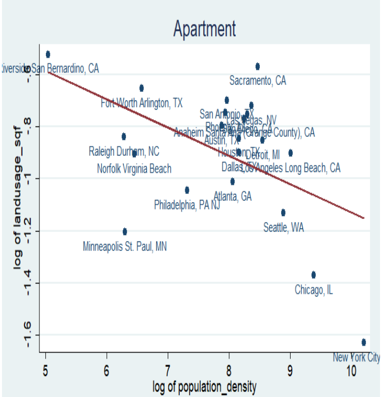


Canada

Empirical Evidence: Land Use

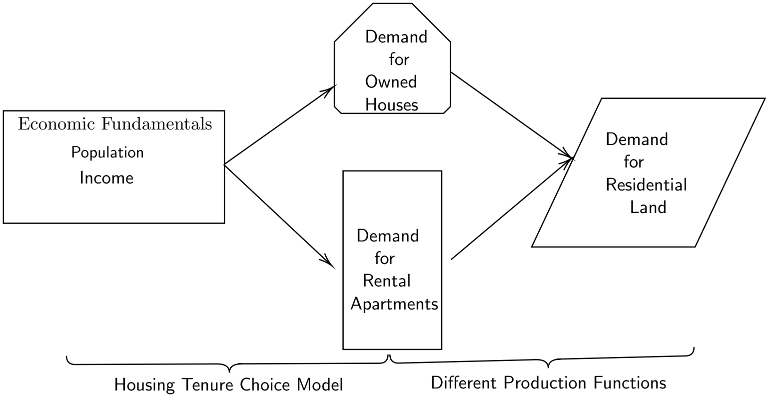
- Land input for building one sqf of living space for apartments ($\frac{1}{stories}$) declines as population density increases
- Land input of building one sqf living space for houses ($\frac{LotSize}{UnitSize}$) does not respond much to population density





Model: Goal

- How demand of land is determined
- Combined with land supply → Land values



Model: General Setup

- K isolated islands, each represents one city
- Household chooses between buying a house and renting an apartment as well as size to buy/rent based on age, income, and wealth
- Competitive developers use land and material to build houses and apartments through different production functions
- Exogenous land supply

Household's Problem

- Household on island k
  - Draw initial wealth and income shock upon born
  - Live up to J periods: hump-shaped income profile
  - Households derive utility from consumption and housing services

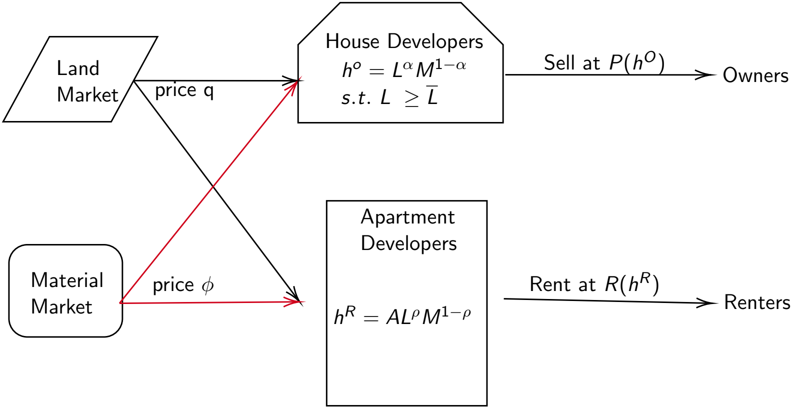
$$V(h, a, \epsilon, j) = max_{c, a', h', \mathbb{1}_{rent} h} ln(c) + \frac{s^{1-\sigma}}{1-\sigma} + \beta \sum_{\epsilon'} \pi(\epsilon' | \epsilon) V(h', a', \epsilon', j+1)$$

$$s = \begin{cases} h & \text{if Rent} \\ \theta_k \mathbb{1}_{j \geq j_o} \zeta h & \text{if Own} \end{cases}$$

  - Household's income: $w_j \bar{w}_k \epsilon$
  - Downpayment requirement:$-a' \leq (1-\gamma) P(h')$

Budget Constraint

Housing supply



Equilibrium Properties

- Housing markets are competitive
  1. House price = total cost of houses

$$
\begin{aligned}
P_{k,t}(h^O) &= f(\alpha) q_{k,t}^{\alpha} \phi_{k,t}^{1-\alpha} h^O \quad if \quad \frac{\alpha \phi_{k,t}}{(1-\alpha) q_{k,t}} \geq \bar{L_k} \\
&= q_{k,t} \bar{L_k} + \frac{h^O}{\bar{L_k}^{\alpha}}^{\frac{1}{1-\alpha}} \phi_{k,t} \quad otherwise
\end{aligned} \tag{1}
$$

  2. Net Present value of rents equals total cost of apartments

$$
\widehat{P_k}(h^R) = \frac{(1-\delta_R) R(h^R)}{r} = \frac{f(\rho) q_{k,t}^{\rho} \phi_{k,t}^{1-\rho} h^R}{A} \tag{2}
$$

Islands

Cities (Islands) differ in

- Population on each island N_k
- Average household income $\bar{w}_k$
- Households' preference towards owning θ_k
- Land supply LS_k
- Material price ϕ_k
- Minimum lot size requirement $\bar{L}_k$

Calibration

- Parameters identical across cities are determined outside of model
  - Utility functions and budget constraint, $\{\eta, \sigma, \beta, r, k_b, k_s, \delta, \delta_R, \pi, \Pi_\epsilon, \zeta, r_m, \tau_w\}$, come from literature
    Detail
  - Parameters in Production Functions $\{\alpha,\ \rho,\ A\}$: Estimated using cross-city variation
- Area Specific Parameters $\{\theta_k, \bar{L_k}\}$ calibrated to homeownership rates of different age groups Detail

Data

Estimating Land Shares

- A 1% increase in land value is associated with α% increase in house price and ρ% increase in apartment rent
- Estimation
  - Regress price and rent separately on transaction-based land value (Albouy, 2017) in 2010
  - Endogeneity: unobserved material prices correlated with land values
  - Instrument land values with geographic constraint on developable land (Saiz, 2010)

	OLS	OLS	IV	IV
VARIABLES	$log(P)$	$log(R)$	$log(P)$	$log(R)$
$log(Land\_Value\_Albouy)$	0.377***	0.202 ***	0.539***	0.280***
	(0.0265)	(0.0158)	(0.0503)	(0.0309)
Constant	7.436***	3.759***	5.479***	2.813***
	(0.319)	(0.192)	(0.608)	(0.373)
Observations	182	182	182	182
R-squared	0.625	0.532	0.510	0.452

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Excess Volatility Puzzle in Housing Market

- Estimated land shares reconcile difference in elasticity of house prices and rents with respect to demand shocks and land supply changes

    1. Saiz (2007): impact of changing income or immigration on median house value is 40% to 80% larger than median rent
    2. Parkhomenko (2016): elasticity of prices w.r.t land scarcity is 0.051, compare to elasticity of rent, 0.024
    3. Greenwald and Guren (2019): Elasticity of prices to credit between 0.30 and 0.38 and a response of rents to credit between 0.21 to 0.26
    4. Miao, Wang and Zha (2014): Correlation between detrended output and price-rent ratio is 0.528

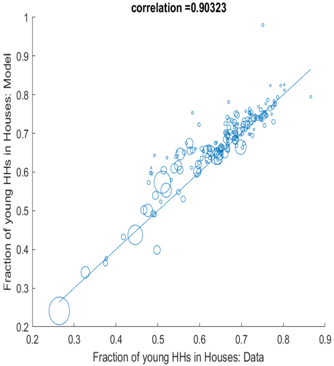
- My estimation: ratio between elasticity of prices and elasticity of rents is around 1.9

Model Fit

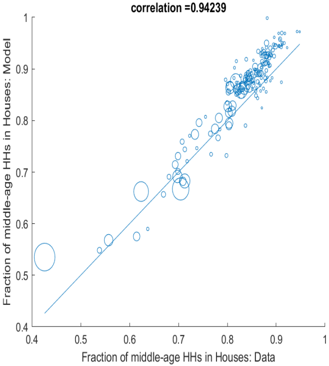
- By construction, fit prices and rents for all cities in 1980
- Match frac of households living in detached/attached houses of different age groups well

Estimated Parameters	Mean	Std		
Relative Productivity A	1.3			
Ownership Premium θ_k	1.7	0.43		
Minimum Lot Size $\bar{L}_k$	0.96	0.1		
Moments	Mean (data)	Std (data)	Mean (model)	Std (model)
Frac in Houses young	0.65	0.097	0.68	0.093
Frac in Houses middle-aged	0.83	0.075	0.86	0.085
Frac in Houses old	0.72	0.113	0.69	0.114

Model Fit: Cross-sectional Frac HH in detached houses



(e) Young:20-34



(f) Middle-aged:35-64

Model Fit: Cross-sectional Frac HH in detached houses

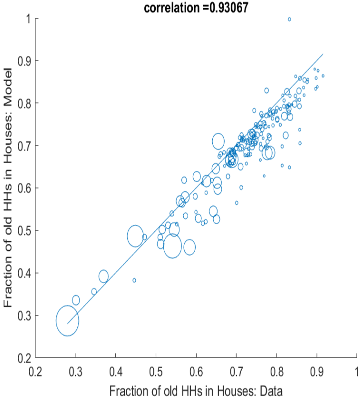


Figure: Old: 65-90

Quantitative Experiments and Summary of Results

- Quantitative Exercise
  1. Feed in total population, income and land supply from 2010
  2. Lower downpayment requirement from 20% to 10%
  3. Solve for equilibrium land price, price for a standard detached house and rent for a standard apartment for each city.

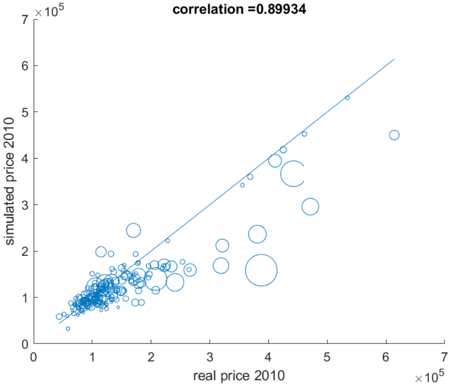
Preliminary Results for Quantitative Experiments

- Model can account for
  - 82% of increase in dispersion of house prices
  - 56 % of increase in dispersion of rents
  - 90% of increase in dispersion of price-rent ratios
  - 37% - 56% of increase in levels

	mean(P/R)	CV(P/R)	mean(P)	CV(P)	mean(R)	CV(R)
1980	19.89	0.21	120900	0.33	6038	0.18
2010	22.15	0.31	146270	0.62	6264	0.27
Simulated 2010 10% downpayment	20.43	0.30	128714	0.55	6081	0.23

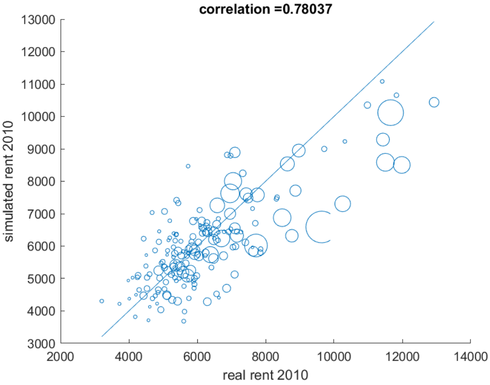
Simulation Results: House Prices

Figure: House Prices in 2010: Model vs Data



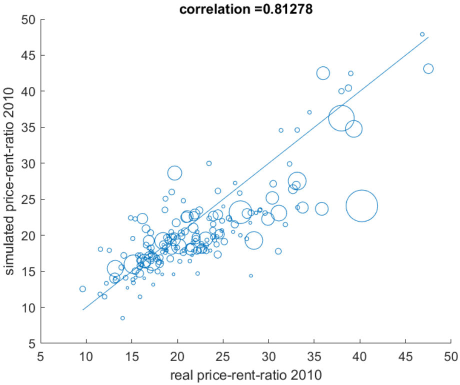
Simulation Results: Rents

Figure: Rents in 2010: Model vs Data



Simulation Results: Price-to-rent Ratio

Figure: Price-rent ratios in 2010: Model vs Data



Discussion Downpayment

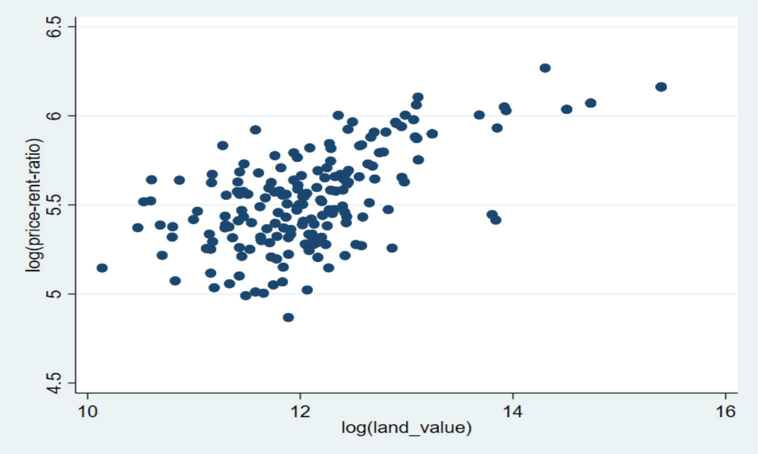
Conclusion

- Difference in land intensity between owner occupied and rental units is important for understanding cross-sectional and cross-time variation the two shelter costs: prices and rents
- Implications on computing CPI: Cost of housing services
  - Rent of Primary Residence
  - Owners' equivalent rent (OER)
- Interpretation of Price-Rent Ratio
  - Indicator of bubble: academics and business press
  - May increase with land values
  - Check whether land becomes scarcer: through lens of model

Thank You !

Empirical Evidence: Price-rent Ratio and Land Values

According to mechanism, price increases more in land values compare to rent.



Land value provided by Albouy (2017) transaction-based

Pre-determined Parameters

Parameter	Meaning	Value	Target or Source
σ	Risk aversion	2.5	Sommer, Sullivan, and Verbrugge(2013)
β	Discount factor	0.96	Sommer, Sullivan, and Verbrugge(2013)
ζ	Discount factor on ownership premium for seniors	0.9116	Fisher and Gervais (2011)
δ	Depreciation rate of owner-occupied units	2.5%	Sommer, Sullivan, and Verbrugge(2013)
δ_R	Management Cost of Rental Properties	41.45%	Goodman (2004)
k_b	Buying cost	2.5%	Yang (2008)
k_s	Selling cost	7%	Yang (2008)
r	Risk-free interest	0.04	Sommer, Sullivan, and Verbrugge(2013)
r_m	Mortgage interest spread	0.015	Amior and Halket (2014)
τ_w	Income Tax	0.2	Piketty and Saez (2007)
τ	Tax on residential properties	0.01	Sommer, Sullivan, and Verbrugge(2013)
ν	AR(1) Coefficient of income	0.75	Fernandez and Wong (2014)
Σ	Innovation of income process	0.45	Chang and Kim (2006)
μ_w	Mean of initial wealth distribution adj by income	3.4	Survey of Consumer Finance 2016
σ_w	std of initial wealth distribution adj by income	28.76	Survey of Consumer Finance 2016

Data

- One period = 5 yrs
- Economic Fundamentals: Census(1980) and ACS(2010)
  - Households 20-80 year olds → age-profile of household income
  - For each MSA
    - Number of Households
    - Average household income → MSA specific income $\bar{w}_k$
- Prices and Rents: Census (1980), ACS(2010) and CMHPI
  - Price: Freddie Mac Conventional Mortgage Home Price Index (CMHPI), an index based on repeated sales, combined with average single family detached home values from 1980 Census
  - Rent: average annual contract rent for 2bd room apartments in multifamily buildings
- Residential Land growth: Land-Use and Land-Cover Data Sets of U.S. Geological Survey
  - Total amount of land used for residential constructions Figure

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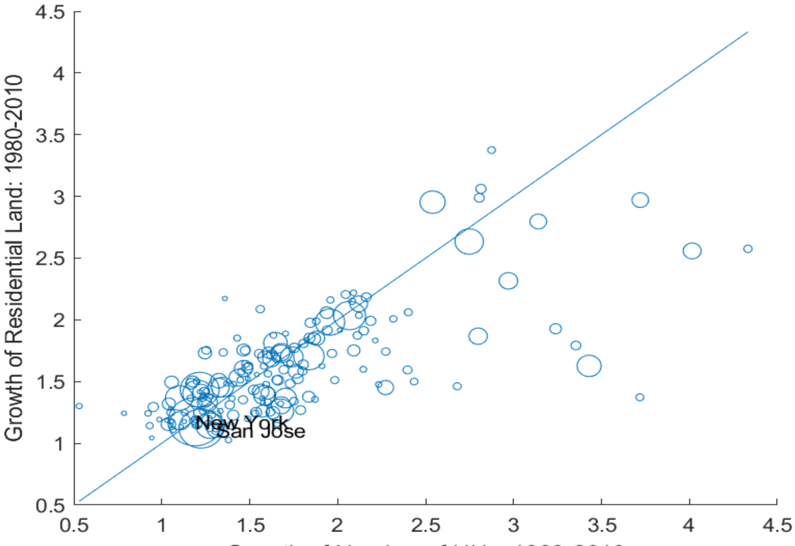
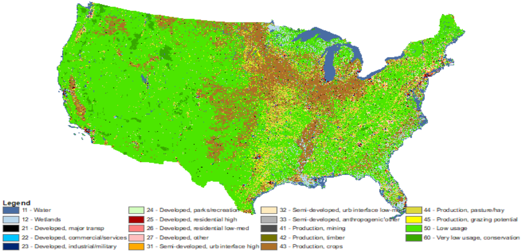
Population Growth and Residential Land Growth



Land-Use and Land-Cover Data: 1982



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Calibration Detail: Area Specific Parameters

For each MSA

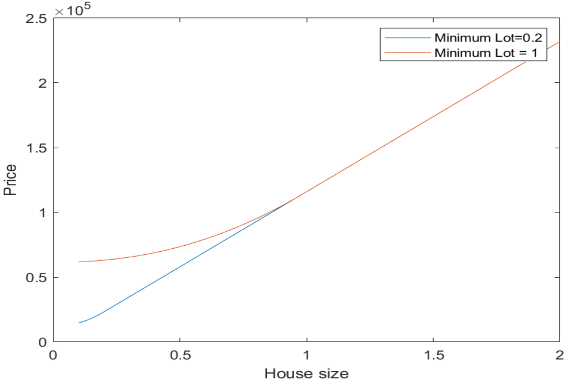
- Guess minimum lot size $\bar{L_k}$
  - Solve for land price and material price in 1980
  - Compute Price and Rent for houses and apartments of different sizes
  - Minimize distance between model generated homeownership rates and data for all age groups

$$\min_{\theta_k} \sum_j \left(\frac{g_j(\theta_k; \bar{L_k}) - g_j^0}{g^0}\right)^2 \tag{3}$$

- Loop over $\bar{L_k}$ to minimize distance between model generated fraction of households living in detached houses and data counter parts

Calibration Strategy Price Function

- θ: Ownership of all age groups
- $\bar{L_k}$ Disproportionally affect young households



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Role of lowering downpayment

- Heterogeneous effect of lowering downpayment across cities

	mean(P/R)	CV(P/R)	mean(P)	CV(P)	mean(R)	CV(R)
1980	19.89	0.21	120900	0.33	6038	0.18
2010	22.15	0.31	146270	0.62	6264	0.27
Simulated 2010 10% downpayment	20.43	0.30	128714	0.55	6081	0.23
Simulated 2010 20% downpayment	20.25	0.28	125911	0.50	6045	0.22

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Bubbles in Big Cities

- Underestimate land price in big cities
- Component missing from model: adjustment cost & Zoning regulation
  1. Adjustment Cost: cost of tearing on existing houses (apartment) and build apartments (houses)
  2. Zoning regulation: illegal on 75% of residential land in many cities to build anything other than detached single-family homes (New York Times)

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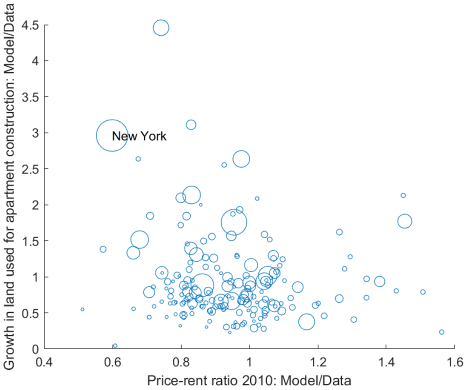
Bubbles in Big Cities

Figure: Price-Rent Ratio and Land Growth for Apartments: Model V.S. Data



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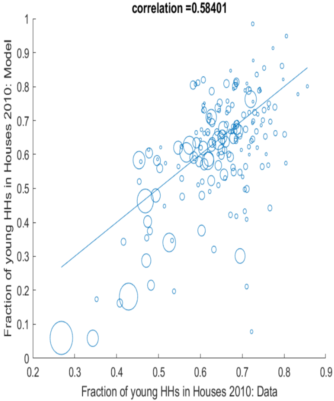
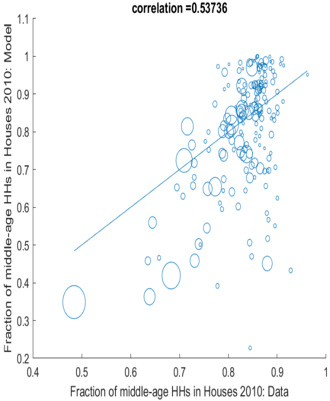
Allowing for Migration

People with high preference towards owning $\rightarrow$ lower ownership premium in big cities over time $\theta_{1980} \leq \theta_{2010}$ $\rightarrow$ over predict fraction of households living in houses in big cities and under predict fraction of households living in houses in small cities when ap $\rightarrow$



(a) Young:20-34



(b) Middle-aged:35-64

Budget Constraint

- Owners

$$
\begin{aligned}
&(k_b P(h') + k_s P(h))\mathbb{1}_{h \neq h'} + c + P(h') + a' + \tau P(h) = \\
&(1-\tau_w) w_j \bar{w}_k \epsilon + \mathbb{1}_{a \geq 0}(1+r)a + \mathbb{1}_{a \leq 0}(1+r+r_m)a + (1-\delta)P(h) \\
&a' \geq -(1-\gamma)P(h') \\
&c \geq 0
\end{aligned}
\tag{4}
$$

- Renters

$$c + (1+k_s)P(h') + R(h) + a' = (1-\tau_w) w_j \bar{w}_k \epsilon + (1+r)a$$

$$-a' \leq (1-\gamma)P(h')$$

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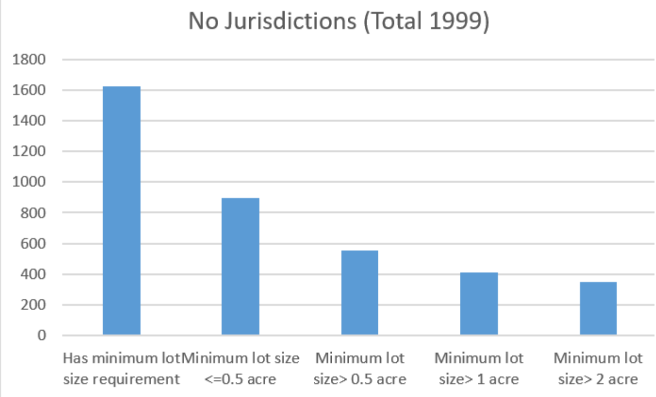
Minimum Lot Size Zoning is Prevalent in U.S. MSAs



Source: Author's calculation using data from Wharton Survey on Residential Land-Usage Regulation

Why not Direct Comparison

- Data issue: Not enough observations to construct constant quality series for rental houses or owned apartments that involve all key markets
  - Rental houses are different from owned houses: median lot size 60% lower
- Economists are aware of difference therefore they compare trends instead of levels
- Owners equivalent rent of primary residence (BLS)
  - Hypothetical question: "If someone were to rent your home today, how much do you think it would rent for monthly, unfurnished and without utilities ?"
  - Only for small set of cities (34)
- Developing sophisticated models to ensure compatibility between rental and owner-occupied properties is beyond scope of this paper due to data availability. It would be interesting to see how much of dispersion of price-rent ratio is due to comparison of different types of dwellings

House Price Growth by Type: Canada

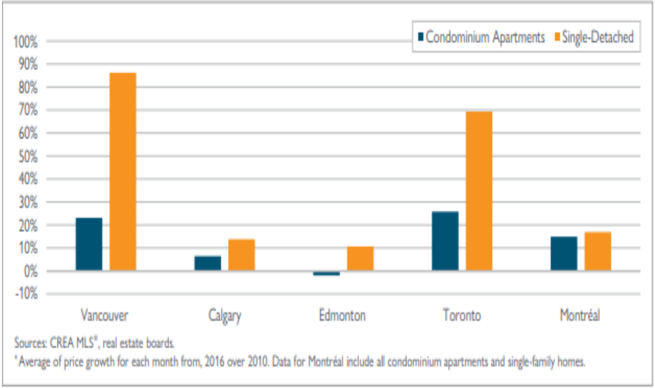


Figure 3 from Examining Escalating House Prices In Large Canadian Metropolitan Centers, CMHC Back

Quality

House of Median Value		Apartment of Median Rent	
Number of Rooms	Freq.	Number of Rooms	Freq.
3	5	3	171
4	135	4	8
5	44		
Number of bedrooms	Freq.	Number of bedrooms	Freq.
2	2	2	179
3	181		
4	1	Age of Structure	Freq.
Age of Structure	Freq.	2-5 yrs	6
6-10 yrs	10	6-10 yrs	63
11-20 yrs	88	11-20 yrs	89
21-30 yrs	79	21-30 yrs	10
31-40 yrs	4	31-40 yrs	8
41+ yrs	3	41+ yrs	3

Cannot Identify θ and A Separately

$$V(a, M, L, \epsilon, j) = maxU(C, \frac{\theta}{\widetilde{A}} M^{1-\alpha} L^{\alpha}) + \beta \sum_{\epsilon'} \pi(\epsilon' | \epsilon) V(a', M', L'\epsilon', j+1)$$

$$(k_b(qL' + \phi M') + k_s(qL + \phi M))\mathbb{1}_{h \neq h'} + c + (qL' + \phi M') + a' + \tau(qL + \phi M)$$
$$= (1 - \tau_w) w_j \bar{w}_k \epsilon + \mathbb{1}_{a \geq 0}(1 + r)a + \mathbb{1}_{a \leq 0}(1 + r + r_m)a + (1 - \delta)(qL + \phi M) \quad (5)$$

Wage response of construction workers

$$log(RelativeWage_{j,2017}) = \alpha + \beta log(Permits_{j,2017}) + \epsilon_j \qquad (6)$$

	Total	1 Unit	2 Units	3 and 4 Units	5 Units or More
	$log(RelativeWage)$	$log(RelativeWage)$	$log(RelativeWage)$	$log(RelativeWage)$	$log(RelativeWage)$
$log(Permits_{2017})$	-0.0225	-0.00255	-0.0101	-0.00107	-0.0235**
	(0.0145)	(0.0265)	(0.0192)	(0.0187)	(0.00919)
Constant	0.133	-0.0590	-0.0277	-0.0767	0.111
	(0.150)	(0.252)	(0.117)	(0.108)	(0.0811)
Observations	51	51	51	51	51
R-squared	0.041	0.001	0.007	0.000	0.070
			Lag of Building Permits		
	Total	1 Unit	2 Units	3 and 4 Units	5 Units or More
	$log(RelativeWage)$	$log(RelativeWage)$	$log(RelativeWage)$	$log(RelativeWage)$	$log(RelativeWage)$
$log(Permits_{2016})$	-0.0224	-0.00297	-0.0140	0.00812	-0.0228**
	(0.0156)	(0.0272)	(0.0225)	(0.0271)	(0.00923)
Constant	0.130	-0.0554	-0.00619	-0.124	0.106
	(0.160)	(0.257)	(0.134)	(0.152)	(0.0831)
Observations	51	51	51	51	51
R-squared	0.039	0.001	0.014	0.005	0.065

Empirical Evidence: Land Use

- Land use for houses are larger than apartments
- Land use for apartments can be flexibly adjusted
- Minimum lot size requirement affects land use

		New York City	Houston	Memphis
Owners	Population Density 2000 (per sq miles)	8158.7	705	377.7
	Ownership Rate	37	54	58
	Fraction in Detached/ Attached House	55	92	100
	Median Unit (sqf)	1900	1800	1500
	Median Lot (sqf)	5500	5500	9000
	Lot Size Distributions for Owner-Occupied Houses			
	<=1/2 acre	41.4	60.4	62.8
	1/2-1 acre	4.2	4.4	13.5
	>=1 acre	54.4	35.2	23.7
Renters	Fraction in Detached/ Attached House	6	25	29
	Median Unit (sqf)	700	800	900
	Median Land Use (unit size / stories)	129	462	450
	Fraction of High Rise Building (>=4 stories)	88	16	4

Author's calculation using AHS

Land use: Houses and Apartments

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Author's calculation using AHS

Calibration Detail: Area Specific Parameters

- $\{\theta_k, \bar{L_k}\}$ calibrated to homeownership rates of young, middle-aged and old households
  - θ_k calibrated to average level of homeownership rates of all age groups