To Own or Rent?
The Effects of Transaction Taxes on Housing Markets

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Motivation

- Real-estate transaction taxes are global, with various names:
  - real-estate transfer tax, land transfer tax, stamp duty
- Growing concern among policy makers:
  - "Henry Review" (2009 Australia); "Mirrless Review" (2010 U.K.)
- Large literature on the effects **within ownership market**
  - Australia: Davidoff & Leigh (17)
  - Canada: Dachis, Duranton & Turner (12)
  - Netherland: Van Ommeren & Van Leuvensteijn (02)
  - Finland: Eerola, *et al.* (19); Määttänen & Terviö (20)
  - Germany: Fritzsche & Vandrei (19)
  - U.K: Besley *et al.*(14); Hilber & Lyytikäinen (17); Best & Kleven (18)
  - U.S: Benjamin *et al.*(93); Slemrod *et al.*(17); Kopczuk & Munroe (15)

This paper

Examines the impact of transaction taxes along both the extensive margin (renting vs. owning) and the intensive margin (moving & transactions)

- New empirical findings using data from Toronto:
  - Buy-to-own sales fall, while buy-to-rent sales increase
  - Price-rent ratio and sales-lease ratio both fall
  - Time-on-the-market and time-to-move both increase
- A novel search model consistent with the empirical findings
  - Choice of renting vs. owning, endogenous moving, free entry of investors
  - Calibrate the model to quantify the GE effects of real-estate transaction tax
- Quantify welfare loss within and across rental and ownership markets
  - Large deadweight loss of tax, with two-third related to the rental market

▸ Related Literature

Part 1: New Facts

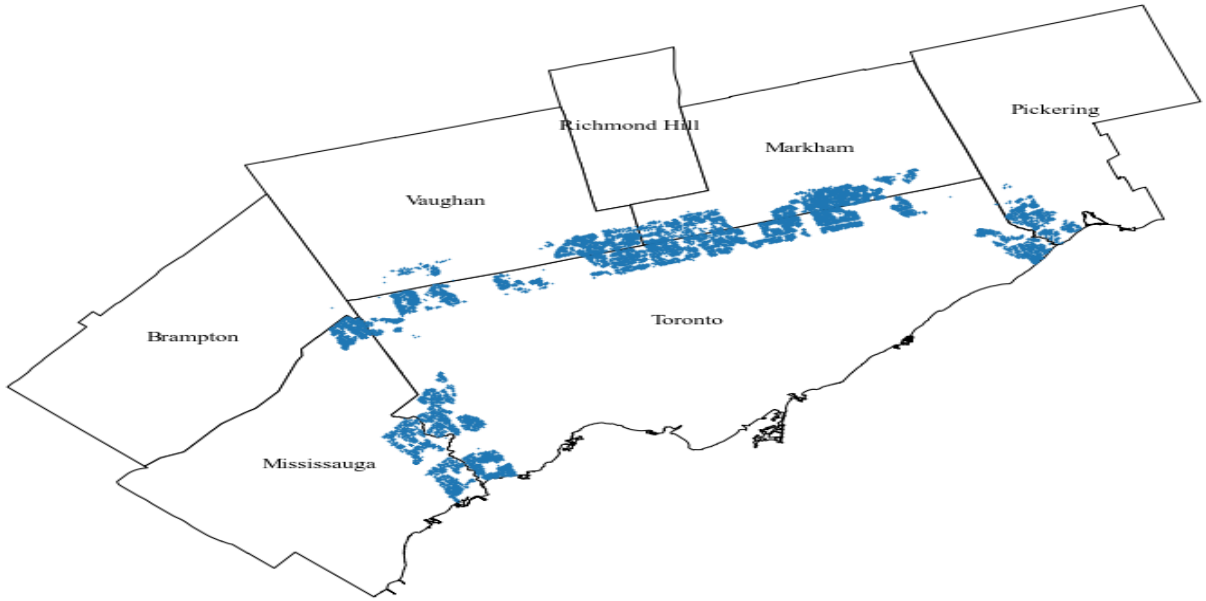
Data

- MLS transaction records in the Greater Toronto Area (2000-2018)
  - Sales: listing and sales price, listing and transaction date, address.
  - Leases: monthly rent and lease term, listing and lease date, address.
  - For transactions after 2006, we observe house characteristics.

- Combine sales and lease to obtain novel measures of transactions
  - Buy-to-rent: followed by being listed for rent within 18 months.
  - Buy-to-sell: followed by being listed for sale within 18 months.
  - Buy-to-own: the remaining.

Empirical strategy

- In February 2008, the city of Toronto implemented the 'municipal land transfer tax' on the top of the original provincial land transfer tax.



Exploit two discrete changes:

1. At the city border: limit the sample to properties in close proximity to each other, but on opposite sides of the city border line
2. On the date the city-level LTT is imposed: before/after Feb 2008

Regression specifications

Baseline specification:

- 3km on each side of the border
- Pre-policy: Jan-06 to Jan-08; post-policy: Feb-08 to Feb-12
- Anticipation effects: indicators for 3 months before/after policy
- Distinct time trends for transactions inside and outside the city

Alternative specifications:

- 5km on each side of the border, and allow homeowners to react to the LTT differently depending on their distance from downtown
- Exclude within 2km of border ('donut' approach)
- Drop all distance restrictions on proximity to the border

Community fixed effects, year fixed effects, month fixed effects, property-type fixed effects, and their interactions. House characteristics in transaction-level regressions.

Summary of Empirical Findings

An increase in the LTT (effective rate from 1.5% to 2.8%)

- Across ownership and rental markets Table
  - Buy-to-own transactions declined by 10%
  - Buy-to-rent transactions increased by 9%
  - Total leases increased relative to sales by 23%
  - Price-to-rent ratio declines by 4%

- Within ownership market Table
  - Homeowners stay longer time in their house by 13%
  - Houses takes longer time to sell by 17%

Part II: A Search Model with Rental and Ownership Markets

A dual ownership and rental markets model of housing

- A city with an ownership market and a rental market.
- Ex-ante identical properties (measure 1) and households (measure ψ).
  - A household can only occupy one property at a time.
  - Households: to buy, to rent, as owner-occupiers or tenant.
  - Properties: for sale, for rent, owner-occupied or renter-occupied.
- Households enter and exit the city at an exogenous rate ρ
- Free entry of buy-to-rent investors, exit at an exogenous rate ρ_I
- Homeowners and investors sell their properties when exit the city .

Search frictions and credit frictions

(I) Probability of viewings:

- Meeting functions $\Upsilon^i(b_i, u_i)$, $i = o, l$, constant returns-to-scale
- Given market tightness $\theta_i = b_i / u_i$,
  - A buyer/renter views properties at rate $q_i(\theta_i)$
  - A property is viewed at rate $\theta_i q_i(\theta_i)$

(II) Idiosyncratic match quality ε:

- Drawn at the time of a viewing with CDF $G_i(\varepsilon)$, $i = o, l$
- Subject to idiosyncratic shocks arriving at rate a_i
  - For owner-occupiers $\epsilon \to \delta_o \epsilon$, $\delta_o < 1$
  - For renter-occupiers $\epsilon \to 0$

(III) Credit cost χ of household entering the ownership market

- New entrants draw an idiosyncratic cost χ to enter the ownership market with CDF $G_m(\chi)$
- The cost χ is a persistent variable, but is redrawn by renters with probability γ when they receive a match-quality shock

Flows within the housing markets

- Transactions:
  - Buyers and sellers meet subject to friction and viewings take place.
  - Transactions happen (for owner-occupiers and tenants) when match quality is above threshold $y_i, i = o, l$
- Mobility:
  - Owner-occupiers move if match quality is below threshold x_o.
  - Tenants move after moving shocks a_l.
- Equilibrium objects:
  - transactions (sales and lease)
  - time-on-the-market
  - mobility
  - prices and rents

Flows across housing markets

- Properties:
  - investors buy properties from ownership market to let in rental market.
  - investors sell rental properties to ownership market upon exit.
- Households:
  - New entrant draws an idiosyncratic cost χ from $G_m(\chi)$ for entering ownership market.
  - A household becomes a buyer if the cost is below a threshold $\chi \leq Z$.
  - The cost χ is a persistent variable, but is redrawn by renters with probability γ when they receive a moving shock.
- Equilibrium objects:
  - buy-to-rent transactions
  - homeownership rate

Household Flows | Houses flows | Ownership market Bellman equation | Rental market Bellman equation

Equilibrium

Equilibrium conditions

- Free entry condition: $K = 0$
- Indifference condition: $Z = B_o - B_l$

Equilibrium Determination

- Given market tightness θ_o, θ_l, cost threshold Z
  - Prices $(P_k, p(\epsilon), R(\epsilon))$ and transaction thresholds (y_o, y_l) are determined by Nash Bargaining within each market.
  - Owner-occupier decides the moving threshold x_o.

  $\rightarrow$ value of being an investors, buyers in the two markets (K, U_o, U_l)

- Free entry condition, indifference condition, flows and stocks determine equilibrium (θ_o, θ_l, Z)

Functional forms | Equilibrium determination | Steady state equilibrium

Effects of higher transaction taxes: Household behaviour

1. Less incentive to be owner-occupier ($Z \downarrow$) $\rightarrow$ fewer first-time buyers
   - Higher tax reduces the joint surplus in the ownership market
2. Homeowners become more tolerant ($x_o \downarrow$) $\rightarrow$ longer time-to-move
   - Higher tax increases the cost of moving
3. Home-buyers become pickier ($y_o \uparrow$) $\rightarrow$ longer time-to-sell
   - Start with a higher match quality to reduce future incidence of moving

Fewer first-time buyers, longer times between moves, and longer time taken to sell all reduce the number of buy-to-own transactions

Effects of higher transaction taxes: Investor behaviour

- Direct effect: higher tax discourages entry of investors
- Equilibrium effects: lower price-to-rent ratio encourages entry
  - Higher rent: more demand for rental properties due to households' reduced incentive to become homeowners
  - Lower price: capitalization effect of higher tax paid by owner-occupiers

Unlike homeowners, landlords do not have to sell and buy when tenants move, which gives buy-to-rent investors an implicit tax advantage:

- Equilibrium effects dominate direct effect: buy-to-rent transactions up

Household and investor behaviour imply a lower homeownership rate

Empirical support for the key mechanism

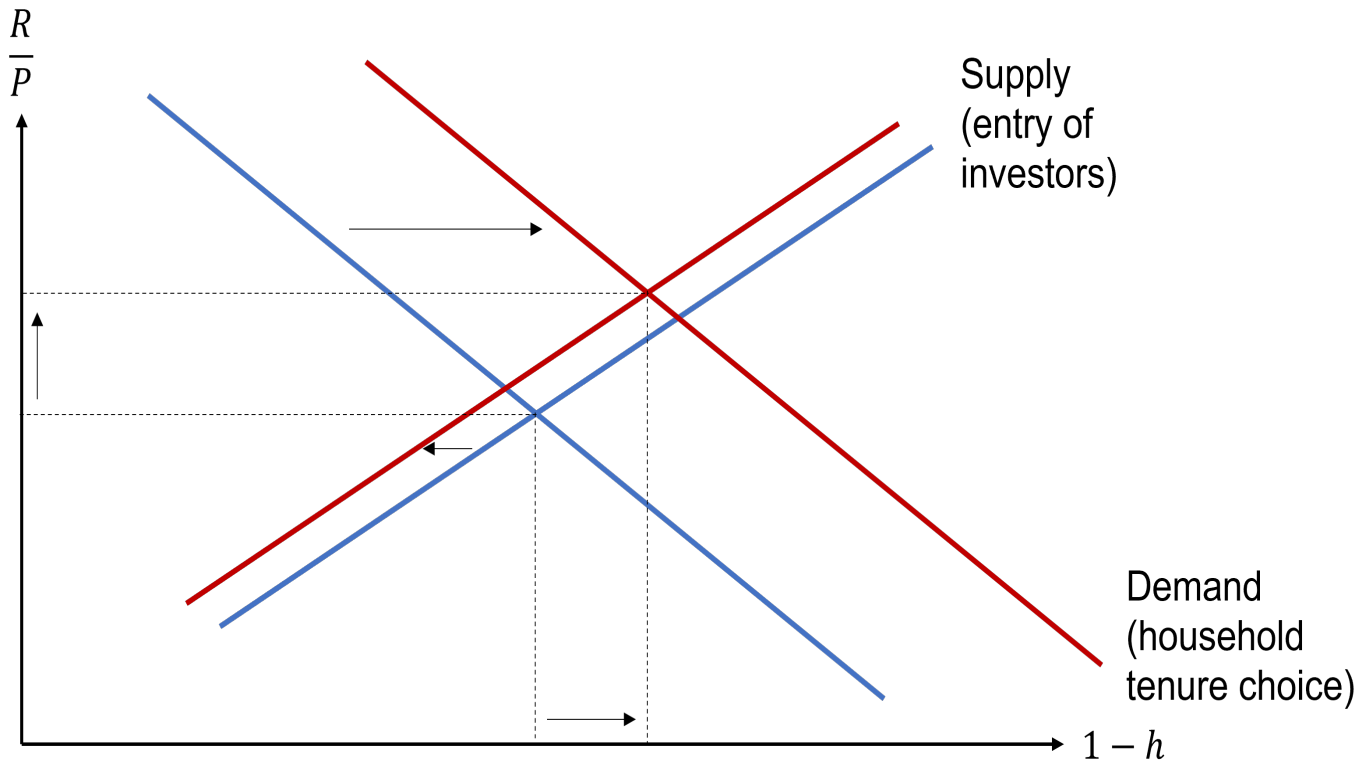
- The longer the holding period of investors, the smaller is the negative direct effect of transaction tax.
- The stock-flow equations for properties implies the steady state relative holding periods:

$$\frac{n_o + \rho}{\rho_I} \approx \left(\frac{1-h}{h}\right) / \left(\frac{\kappa}{1-\kappa}\right).$$

- The long holding period of investors is an implication of investors' share of transaction flows ($\kappa = 0.05$) being smaller than their share of the stock ($1 - h = 0.46$).

House flows

Intuition for Heterogeneous Effect of Transaction Tax



- Direct effect of a transaction tax on reducing entry of investors is smaller than on increasing entry of households.
- Rent-to-price ratio increases and homeownership rate fall.

Connections between Model and Empirical Findings

- Empirical results highlight heterogenous effects of transaction taxes across **owner-occupied and rental markets**, the role of **search frictions** through tax effect on time-to-sell, and the role of **moving decision** on time-to-move.
- The empirical results compares the City of Toronto to other areas in the GTA before and after LTT increase.
- If these two regions are segmented markets, then the model focusing on one isolated region with a fixed population does the work.
- Extension with mobility across regions: larger fall in house prices but similar effects on quantities and welfare.
    - Higher tax lower the expected value of entering city. If housing stock is fixed, since houses must be owned or rented by someone, the value of living inside the city must adjust through a fall in house prices.

Part III: Quantitative Effect of Higher Transaction Taxes

Calibration

- Calibrate to Toronto in 2007, before the LTT change
- Three broad sets of targets:
  1. Extensive margin across ownership and rental markets:
     - Homeownership rate, buy-to-rent as fraction of all transactions, fraction of first-time buyers, age difference between owners and renters, price-rent ratio, mortgage interest rate spreads
  2. Search behavior and associated costs:
     - Time-on-the-market, viewings per sale, time between moves, transaction costs relative to prices and rents
     - Match the model-implied moving-rate response to the LTT change to the empirical estimate
  3. Functional forms and directly set some parameters
     - Equal numbers of properties and households, no incentive for entry of more households, Cobb-Douglas meeting functions, Nash bargaining with bargaining powers equal to meeting-function elasticities, Pareto distribution of match quality, log Normal distribution of credit costs

Calibration targets Parameters

Quantitative effects of a higher transaction tax

Variable	Model prediction	Econometric evidence
Time-to-move for homeowners	13% (matched)	13%
Buy-to-own (BTO) transactions	−17%	−10.1%
Buy-to-rent (BTR) transactions	5.0%	8.9%
Time-to-sell	7.8%	16.5%
Leases-to-sales ratio	21%	23%
Price-to-rent ratio	−1.5%	−3.9%
Average sales price	−1.4%	−2.0%
Homeownership rate	−4.5% (−2.4 p.p.)	-
Transaction tax revenue	44%	-
Effective LTT tax rate	Increased from 1.5% to 2.8% (1.3 p.p.)	

Welfare effects of the transaction tax

Variable	Result
Welfare loss relative to increase in tax revenue	113%
(1) Across markets	60%
(2) Within rental market	14%
(3) Within ownership market	40%

- Across-market loss: fall in homeownership rate
  - Magnitude depends mainly on the distribution of credit costs, which is calibrated using data on mortgage rate paid by average and marginal buyers.
- Within-market loss: match quality and non-tax transaction costs
  - Ownership market: large, indivisibility of housing — tax on whole value of property, not only the marginal improvement from moving
  - Rental market: more non-tax transaction costs are incurred

Welfare function | Key margin | Buy-to-let investor | Housing consumption tax

Summary of the paper

- Document three novel effects of transaction taxes:

  (i) Buy-to-rent transactions rise while owner-occupier transactions fall

  (ii) Lower price-to-rent ratio and lower sales-to-leases ratio

  (iii) Increase in time taken for properties to sell

- Build a search model with free entry of investors, and where households choose renting or owning, and make moving decisions
- A higher transaction tax distorts the allocation of properties across the two markets by reducing the homeownership rate, and within the ownership market by reducing mobility
- Find a large welfare loss (113%) with half due to the reallocation of properties and households across rental and ownership market.

Additional Slides

Estimated LTT effects across rental and ownership markets

Dependent variable	(1)	(2)	(3)	(4)
log (*#Leases/#Sales*)	0.234**	0.242***	0.236**	0.264***
	(0.117)	(0.082)	(0.100)	(0.063)
Observations	1355	2660	1782	7730
log (*Price/Rent*)	-0.039**	-0.026*	-0.031*	-0.037**
	(0.019)	(0.015)	(0.017)	(0.013)
Observations	1355	2660	1782	7730
log (*#BTO sales*)	-0.101**	-0.097**	-0.087*	-0.122***
	(0.047)	(0.044)	(0.049)	(0.033)
Observations	3736	6363	3811	17190
log (*#BTR sales*)	0.089*	0.099**	0.117**	0.110*
	(0.047)	(0.045)	(0.053)	(0.058)
Observations	531	1031	670	2857
Distance threshold	3km	5km	5km	All
City indicators ± 3 m.	Yes	Yes	Yes	Yes
City time trends	Yes	Yes	Yes	Yes
Distance LTT trends		Yes	Yes	Yes
Donut hole			2km	

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Estimated LTT effects on mobility and time-on-the-market

	(1)	(2)	(3)	(4)
	Dependent variable: The event of moving			
LTT	-0.130**	-0.194***	-0.232***	-0.228***
	(0.064)	(0.053)	(0.088)	(0.042)
log(*Original purchase price*)	-0.095**	-0.076*	-0.103**	-0.079***
	(0.046)	(0.043)	(0.048)	(0.023)
log φ	0.513***	0.523***	0.519***	0.526***
	(0.010)	(0.007)	(0.010)	(0.005)
Observations	1,691,369	2,831,897	1,651,935	5,719,326
	Dependent variable: log (*Time-on-the-market*)			
LTT	0.165***	0.163***	0.162***	0.131***
	(0.028)	(0.028)	(0.051)	(0.019)
Observations	20,937	37,397	24,569	185,080
Distance threshold	3km	5km	5km	All
House characteristics	Yes	Yes	Yes	Yes
City indicators ± 3 m.	Yes	Yes	Yes	Yes
City time trends	Yes	Yes	Yes	Yes
Distance LTT trends		Yes	Yes	Yes
Donut hole			2km	

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Additional Slides

Related literature

- Empirically, study same LTT as Dachis, Duranton & Turner (2012)
  - They estimate effects on prices and transactions within the ownership market and infer a small welfare loss.
  - We estimate a full list of housing market variables and find a large welfare loss taking into account the general-equilibrium effects across ownership and rental markets.

- Theoretically, our work relates to:
  - Search models with transaction taxes: Lundborg & Skedinger (1999)
    - We allow for endogenous moving and a rental market
  - OLG models of housing with transaction taxes: Cho, Li &, Uren (2021), Kaas, Kocharkov, Preugschat and Siassi (2021)
    - We highlight the indivisible nature of housing, and separate buy-to-rent from buy-to-own transactions

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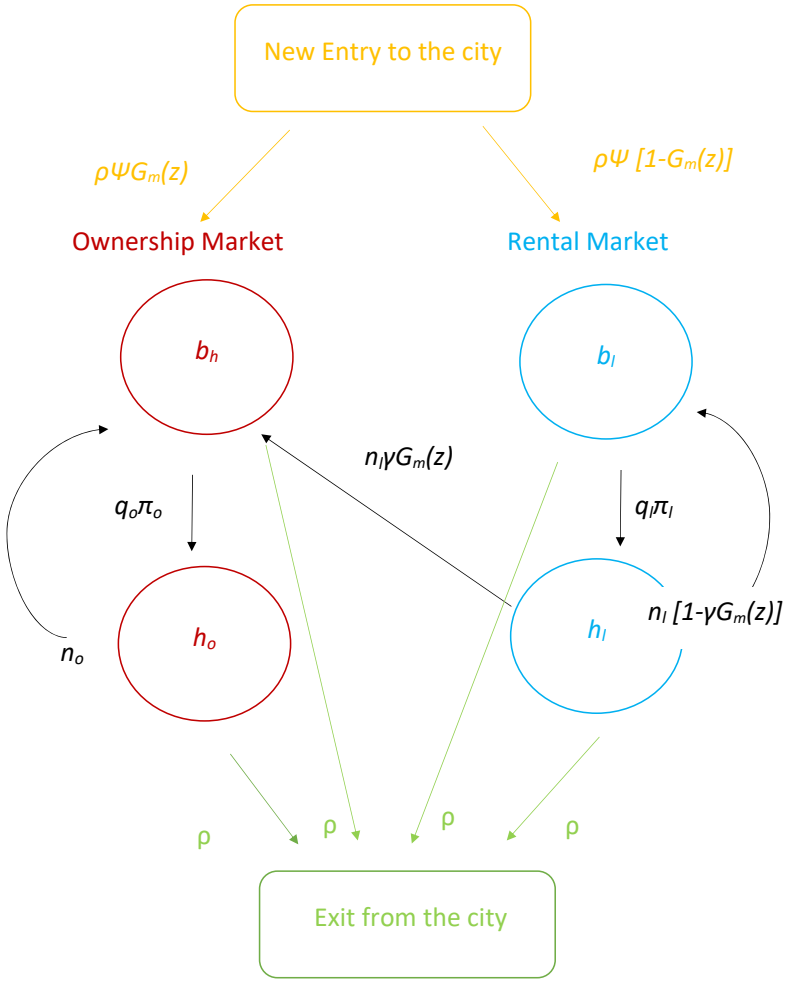
Flows and stocks: households



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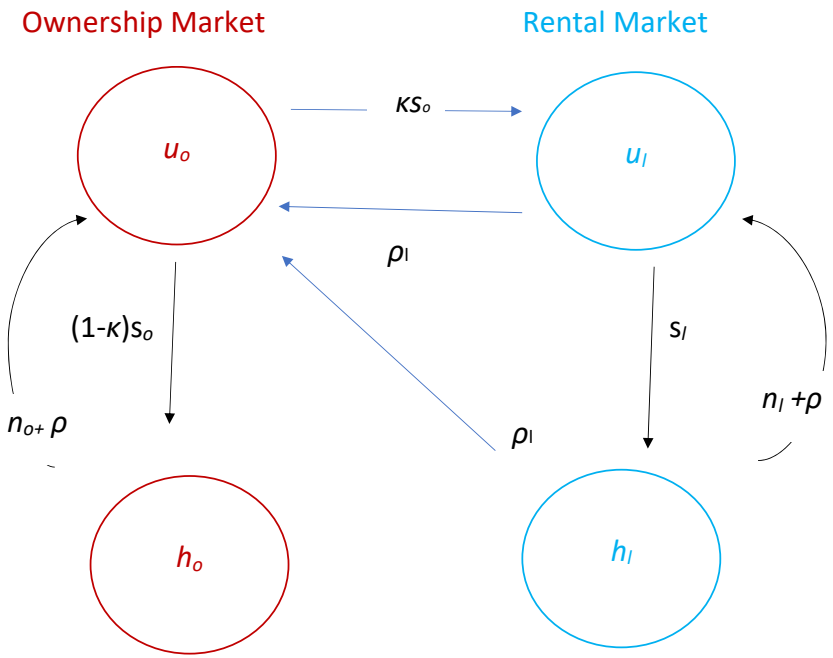
Flows and stocks: properties



κ is the equilibrium fraction of buy-to-rent transactions
s_o is the sales rate in the ownership market

Flows | Holding period

The ownership market

Investor K, home-buyer B_o, property-for-sale U_o and owner-occupier H:

$$rK = -F_k + q_o \left(U_l - (1+\tau_k) P_k - C_k - K \right) + \dot{K} \, .$$

$$rB_o = -F_h + q_o \int \max \left\{ H(\varepsilon) - C_h - (1+\tau_h) p(\varepsilon) - B_o, 0 \right\} \mathrm{d}G_o(\varepsilon) - \rho B_o + \dot{B}_o \, .$$

$$rU_o = -M + \theta_o q_o \left((1-\xi) \int \max \left\{ p(\varepsilon) - C_u - U_o, 0 \right\} \mathrm{d}G_o(\varepsilon) + \xi \max \left\{ P_k - C_u - U_o, 0 \right\} \right) + \dot{U}_o \, .$$

$$rH(\varepsilon) = \varepsilon - M + a_o \left(\max \left\{ H(\delta_o \varepsilon), B_o + U_o \right\} - H(\varepsilon) \right) + \rho (U_o - H(\varepsilon)) + \dot{H}(\varepsilon) \, .$$

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The rental market

Property-to-let U_l, landlord $L(\epsilon)$, renter B_l and tenant $W(\epsilon)$:

$$rU_l = -M + \theta_l q_l \int \max\{L(\epsilon) + \Pi(\epsilon) - C_l - U_l, 0\} \mathrm{d}G_l(\epsilon) + \rho_l(U_o - U_l) + \dot{U}_l \,.$$

$$rL(\epsilon) = R(\epsilon) - M - M_l + (a_l + \rho)\left(\max\{U_l, U_o\} - L(\epsilon)\right) + \rho_l(U_o - L(\epsilon)) + \dot{L}(\epsilon) \,.$$

$$rB_l = -F_w + q_l \int \max\left\{W(\varepsilon) - \Pi(\epsilon) - C_w - B_l, 0\right\} \mathrm{d}G_l(\varepsilon) - \rho B_l + \dot{B}_l \,.$$

$$rW(\epsilon) = \gamma(a_l + \rho_l)\left(G_m(Z)(B_o - \bar{\chi}) + (1 - G_m(Z))B_l - W(\epsilon)\right) + \epsilon - R(\epsilon) + (1-\gamma)(a_l + \rho_l)(B_l - W(\epsilon)) - \rho W(\epsilon) + \dot{W}(\epsilon)$$

$\bar{\chi} = E[\chi | \chi \leq Z]$ is the expected cost conditional on actually paying it.

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Functional forms

- Cobb-Douglas meeting functions:

$$\Upsilon^i(b_i, u_i) = A_i b_i^{1-\eta_i} u_i^{\eta_i}, \quad \text{hence} \quad q_i(\theta_i) = A_i \theta_i^{-\eta_i},$$

- Match quality is drawn from Pareto distributions

$$G_i(\varepsilon) = 1 - \left(\frac{\varepsilon}{\zeta_i}\right)^{-\lambda_i} \quad \text{for} \quad i \in \{0, 1\}, \quad \text{and where} \quad \lambda_i > 1,$$

  Expected match quality from a viewing is $E_i[\varepsilon] = \zeta_i \lambda_i / (\lambda_i - 1)$.
- Credit cost χ is drawn from a log Normal distribution

$$G_m(\chi) = \Phi\left(\frac{\log \chi - \mu}{\sigma}\right), \quad \text{implying} \quad \bar{\chi} = e^{\mu + \frac{\sigma^2}{2}} \frac{\Phi\left(\frac{\log Z - \mu - \sigma^2}{\sigma}\right)}{\Phi\left(\frac{\log Z - \mu}{\sigma}\right)},$$

where $\Phi(\cdot)$ is the standard Normal CDF.

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Ownership market decisions

- When a seller meets a home-buyer,

$$\Sigma_o^h(\varepsilon) = H(\varepsilon) - (1+\tau_h)p(\varepsilon) - C_h - B_o\,, \quad \Sigma_o^u(\varepsilon) = p(\varepsilon) - C_u - U_o\,,$$

The joint surplus is $\Sigma_o(\varepsilon) \equiv \Sigma_o^h(\varepsilon) + \Sigma_o^u(\varepsilon)$, Nash bargaining implies

$$p(\varepsilon) = C_u + U_o + \omega_o^* \Sigma_o(\varepsilon) \quad \text{where} \quad \omega_o^* \equiv \frac{\omega_o}{1+\tau_h(1-\omega_o)}\,.$$

Transactions happen when $\epsilon \geq y_o$, where $\Sigma_o(y_o) = 0$.

- The moving threshold x_o is defined as $H(x_o) = B_o + U_o$.
- Transaction taxes affect transactions and prices through both transaction and moving decision.

Rental market decision (I)

- The bargaining problem for new rental contracts is the same as for continuing rental contracts.
  - The transaction costs C_w, C_l are a type of fixed matching cost, which are sunk at the time of the rent negotiation.
  - The tenant's homeownership cost χ does not change except after a moving shock.
- The surpluses of the tenant and the landlord are

$$\Lambda^w(\epsilon) = W(\varepsilon) - B_l\,, \quad \text{and} \quad \Lambda^l(\epsilon) = L(\varepsilon) - U_l\,.$$

The joint surplus is $\Lambda(\varepsilon) = \Lambda^w(\varepsilon) + \Lambda^l(\varepsilon)$, Nash bargaining implies

$$\Lambda^w(\varepsilon) = (1-\omega_l)\Lambda(\varepsilon)\,, \quad \text{and} \quad \Lambda^l(\varepsilon) = \omega_l\Lambda(\varepsilon)\,.$$

Rental market decision (II)

- When a potential tenant meet with the landlord, if the landlord agrees the tenant can move in after paying a fee $\Pi(\epsilon)$ then the two parties incur costs C_l and C_w, respectively.
- The surplus to a potential tenant and landlord:

$$\Sigma_l^w(\varepsilon) = W(\varepsilon) - \Pi(\varepsilon) - C_w - B_l\,, \quad \Sigma_l^l(\varepsilon) = L(\varepsilon) + \Pi(\varepsilon) - C_l - U_l\,.$$

The joint surplus is $\Sigma_l(\varepsilon) \equiv \Sigma_l^w(\varepsilon) + \Sigma_l^l(\varepsilon)$, Nash bargaining implies:

$$\Pi(\varepsilon) = \Pi = (1-\omega_l)C_l - \omega_l C_w.$$

- Transactions happen when $\epsilon \geq y_l$, where $\Sigma_l(y_l) = 0$.

Investor decision

- The surpluses to an investor and a seller are:

$$\Sigma_k^k = U_l - (1+\tau_k)P_k - C_k - K\,, \quad \text{and} \quad \Sigma_k^u = P_k - C_u - U_o\,.$$

  Their joint surplus is $\Sigma_k \equiv \Sigma_k^k + \Sigma_k^u$, Nash bargaining implies:

$$\Sigma_k^k = (1-\omega_k^*)\Sigma_k \quad \Sigma_k^u = \omega_k^*\Sigma_k\,, \quad \omega_k^* \equiv \frac{\omega_k}{1+\tau_k(1-\omega_k)}\,.$$

- The free entry condition implies:

$$\Sigma_k = \frac{F_k}{(1-\omega_k^*)q_o(\theta_o)}.$$

- Positive joint surplus, $\Sigma_k \geq 0$, implies $U_l > U_o$.
  $\rightarrow$ After purchasing a property, an investor strictly prefers to let it out in the rental market.

Steady state equilibrium

- The law of motions for the stock of properties and households in each of their corresponding four states are used to determined steady state allocation of properties and households: $h_o, h_l, u_l, u_o, b_o, b_l$.
- The inflow and outflow rates of different states depend on
  - The endogenous moving rate in the ownership market
  - The endogenous transaction rates in both markets
  - The endogenous entry into ownership, cost threshold Z
  - The exogenous transition rates due $\rho, \rho_l, a_l, \gamma$
- Steady state equilibrium objects with explicit formulas:
  - The moving rate of owner-occupier n_o, thus expected length of stay.
  - Time-on-the-market in both markets.
  - The homeownership rate defined as $h = h_o + (1 - \kappa)u_o$.
  - The average number of viewings ν_o and time-to-buy.
  - The average age difference between owner-occupiers and tenants α.
  - The fraction of first-time buyers ϕ

Back Steady state conditions

Ownership market steady state conditions

- The expected surplus $\Sigma_o \equiv \int_{y_o} \Sigma_o(\varepsilon) \mathrm{d}G_o(\varepsilon)$ is:

$$\Sigma_o = \frac{\zeta_o^{\lambda_o}}{(r+\rho+a_o)(\lambda_o-1)(1+\tau_h\omega_o^*)} * \left(y_o^{1-\lambda_o} + \frac{a_o \delta_o^{\lambda_o} x_o^{1-\lambda_o}}{r+\rho+a_o\left(1-\delta_o^{\lambda_o}\right)} \right) .$$

- Given market tightness θ_o, the equilibrium thresholds (x_o, y_o) satisfy

$$y_o = x_o + (r+\rho+a_o)\left(C_h + C_u + \tau_h \left(C_u - \frac{M}{r} + \frac{\theta_o q_o(\theta_o)\omega_o^* \Sigma_o}{r} \right) \right) .$$

$$x_o + F_h = \left(1 - \omega_o^* + \omega_o^* \theta_o\right) q_o(\theta_o) \Sigma_o .$$

- The average transaction price P is

$$P = \frac{1}{\pi_o} \int_{y_o} P(\epsilon) \mathrm{d}G_o(\epsilon) = \frac{\omega_o^* \Sigma_o}{\pi_o} + C_u + U_o .$$

The rental market steady state conditions

- Given z, θ_l, the equilibrium threshold y_l satisfies:

$$y_l = M_l - F_w + (r + a_l + \rho)(C_w + C_l) - a_l \varsigma_l G(z)(z - \bar{z}) + (1 - \omega_l + \omega_l \theta_l) q_l(\theta_l) \Sigma_l .$$

- The joint surplus is

$$\Sigma_l = \frac{\zeta_l^{\lambda_l} y_l^{1-\lambda_l}}{(\lambda_l - 1)(r + a_l + \sigma_l + \rho)} .$$

- The average rent R is:

$$R = M_l - \omega_l (r + a_l + \rho)(C_w + C_l) + \omega_l (r + a_l + \rho + \theta_l q_l(\theta_l) \pi_l(y_l)) \frac{\Sigma_l}{\pi_l(y_l)} .$$

- Total lease is $u_l s_l$ where $s_l = \theta_l q(\theta_l) \pi_l(y_l)$

Market tightness

- Using the value functions, the free entry condition and indifference condition becomes:

$$K = 0: \quad \omega_I \theta_I \frac{q_I}{r} \Sigma_I = (1+\tau_k)\omega_o^* \theta_o \frac{q_o}{r} \Sigma_o + (1+\tau_k \omega_k^*)\Sigma_k + C_k + (1+\tau_k) C_u - \tau_k \frac{M}{r}$$

$$z = B_o - B_I: \quad (1-\omega_o^*) q_o \Sigma_o = (1-\omega_I) q_I \Sigma_I + (r+\rho) z + F_h - F_w \,.$$

- Together they solve for equilibrium market tightness θ_o, θ_I given a cost threshold z.

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Calibration targets

Targets	Notation	Value
Directly imposed targets		
Equal numbers of households and properties	ψ	1
No incentive for further entry of households into the city	B_e	0
Bargaining powers equal to meeting-function elasticities	$\omega_o/\eta_o = \omega_l/\eta_l$	1
Empirical targets		
Average buy-to-own transaction price	P	\$402k
Effective land transfer tax for all buyers	$\tau_h = \tau_k$	1.5%
Homeownership rate	h	54%
Fraction of purchases made by buy-to-rent investors	κ	5.4%
Fraction of first-time buyers among all home-buyers	ϕ	40%
Difference in average ages of owner-occupiers and renters	α	8.3
Average price-rent ratio for same properties	P_k/R	14.5
Price paid by investors relative to average paid by home-buyers	P_k/P	99%
Non-tax transaction costs of buyers relative to price	$C_h/P = C_k/P_k$	0%
Property maintenance costs relative to price	M/P	2.6%
Landlords' extra maintenance/management costs relative to rent	M_l/R	8%
Seller transaction costs relative to price	C_u/P	4.5%
Landlord transaction costs relative to rent	C_l/R	8.3%
Fraction of landlord transaction costs charged to tenant	Π/C_l	0%
Flow search costs of home-buyers relative to price	F_h/P	3.1%
Flow search costs of investors relative to home-buyers	F_k/F_h	1
Flow search costs of tenants relative to home-buyers	F_w/F_h	1.1
Sellers' average time on the market	T_{so}	0.161
Buyers' average time on the market	T_{bo}	0.206
Landlords' average time on the rental market	T_{sl}	0.066
Average viewings per sale	ν_o	20.6
Average viewings per lease	ν_l	10.3
Average time between moves for owner-occupiers	T_{mo}	9.25
Average time between moves for tenants	T_{ml}	3.04
Percentage decline of owner-occupier moving rate after new LTT	β	13%
Capitalized credit costs of marginal home-buyer relative to price	Z/P	0.48
Ratio of credit costs of marginal and average home-buyers	$Z/\bar{\chi}$	2.11
Sources of the targets for credit costs		
Risk-free real interest rate	r_f	1.86%
Average real mortgage interest rate	$\bar{r}_c$	4.93%
Real mortgage interest rate of the marginal home-buyer	r_c	6.43%
Initial loan-to-value ratio of first-time buyers	ℓ	80%
Mortgage term	T_c	25

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Calibrated parameters

Parameter description	Notation	Value
Number of households relative to the number of properties	ψ	1
Discount rate for future housing-market payoffs	r	3.3%
Households' exit rate from the city	ρ	4.3%
Investors' exit rate	ρ_l	0.7%
Property maintenance cost	M	10.4
Landlords' extra maintenance/management costs	M_l	2.2
Minimum new match quality in the ownership market	ζ_o	32.1
Minimum new match quality in the rental market	ζ_l	23.4
Home-buyer shape parameter of new match quality distribution	λ_o	30.1
Tenant shape parameter of new match quality distribution	λ_l	33.3
Arrival rate of match quality shocks in the ownership market	a_o	8.1%
Arrival rate of match quality shocks in the rental market	a_l	27.9%
Size of match quality shock in ownership market	δ_o	0.850
Fraction of tenants drawing new credit cost after moving shock	γ	8.3%
Parameter for mean of the distribution of credit costs	μ	5.0
Parameter for standard deviation of the distribution of credit costs	σ	0.67
Transaction costs of buyers excluding taxes	$C_k = C_h$	0
Transaction costs of sellers	C_u	18.1
Transaction costs of landlords	C_l	2.3
Transaction costs of tenants	C_w	0.83
Flow search costs of home-buyers and investors	$F_k = F_h$	12.6
Flow search costs of prospective tenants in the rental market	F_w	13.6
Viewing productivity parameter in the ownership market	A_o	112
Viewing productivity parameter in the rental market	A_l	170
Elasticity of ownership-market meetings with respect to sellers	η_o	0.458
Elasticity of rental-market meetings with respect to landlords	η_l	0.733
Bargaining power of sellers meeting a home-buyer	ω_o	0.458
Bargaining power of sellers meeting an investor	ω_k	0.218
Bargaining power of landlords meeting a prospective tenant	ω_l	0.733

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Welfare analysis

The flow value of steady-state utility net of costs averaged across all households is:

$$r\Omega = h_o Q_h + h_l Q_l - b_h F_h - b_k F_k - b_l F_w - S_o((1-\kappa)C_h + \kappa C_k + C_u) \\ - M - h_l M_l - S_l(C_l + C_w) - (\gamma n_l h_l + \rho\psi) G_m(Z)\bar{\chi} + \dot{\Omega}\,,$$

- The welfare measure can be calculated together with a pair of differential equations for the average match qualities Q_h and Q_l:

$$\dot{Q}_h = \frac{(1-\kappa)s_o u_o}{h_o}\left(\frac{\lambda_o}{\lambda_o - 1}y_o - Q_h\right) - (a_o - n_o)\left(Q_h - \frac{\lambda_o}{\lambda_o - 1}x_o\right)\,,$$

$$\dot{Q}_l = \frac{s_l u_l}{h_l}\left(\frac{\lambda_l}{\lambda_l - 1}y_l - Q_l\right)\,.$$

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Key margin for the quantitative effects across markets

- The mass of marginal buyers is the key margin.
- An important data target determining the mass is the mortgage rate gap between the marginal and average buyers:
  $\uparrow$ **gap** $\rightarrow \downarrow$ **mass of marginal buyers**
- Based on micro-level mortgage data from the Bank of Canada, the gap between the average borrowers and borrowers with low credit scores is around 3% for a typical 5-year mortgage contracts. The marginal buyer is likely to pay lower rate beyond the first 5 years, the baseline uses a 1.5% gap.
- If we were to increase the gap to the 3%, the implied welfare cost will be smaller at 79% where 40% of the total loss due to the presence of rental market. This can be view as the lower bound.
- The smaller welfare cost is due to a smaller predicted increase in buy-to-rent transactions at 2%. Full table

The role of buy-to-rent investors

- Novel effect: increase transaction tax increases distortions in the housing stock across the ownership and rental markets through increase entry of buy-to-rent investors.
- Same increase in τ_h as before, increase τ_k to a level so that homeownership rate remains unchanged (τ_k from 1.5% to 5.7%).
- Much smaller welfare loss (42% instead of 113%).
  Tax revenue increases slightly (up by 52% instead of 44%).
- Increasing τ_k further to raise homeownership would ultimately lead to larger welfare costs as uncreditworthy households are forced into ownership because of a lack of rental.
- Deep-pocketed investors provides access to housing without everyone needing to pay credit costs.

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A tax on housing consumption

Variable	Higher transaction tax	Housing consumption tax
Time-to-move for homeowners	13%	−0.18%
Buy-to-own (BTO) transactions	−17%	0.26%
Buy-to-rent (BTR) transactions	5.0%	−0.10%
Time-to-sell	7.8%	−0.12%
Leases-to-sales ratio	21%	−0.34%
Price-to-rent ratio	−1.5%	−1.58%
Average sales price	−1.4%	−1.57%
Homeownership rate	−4.5%	0.09%
Welfare loss as a fraction of tax revenue	113%	−0.02%
Decomposition of welfare cost		
Across-market welfare loss	60%	−0.013%
Within-ownership market welfare loss	40%	−0.002%
Within-rental-market welfare loss	14%	−0.003%

Notes: This table compares the simulation results of a rise in the housing consumption tax (through M) with the baseline results of a rise in the transaction tax reported in Table 5. The initial transaction tax is set at 1.5% in both cases, and the increase in tax in each case yields a 44% increase in tax revenue. The responses of variables are reported as log differences.

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Tax effects with a 3% gap

Variable	Model prediction	Econometric evidence
Time-to-move for homeowners	13% (matched)	13%
Buy-to-own (BTO) transactions	−15%	−10.1%
Buy-to-rent (BTR) transactions	1.9%	8.9%
Time-to-sell	8.6%	16.5%
Leases-to-sales ratio	15%	23%
Price-to-rent ratio	−1.8%	−3.9%
Average sales price	−1.9%	−2.0%
Homeownership rate	−1.6% (−0.9 p.p.)	-
Transaction tax revenue	46%	-
Effective LTT tax rate	Increased from 1.5% to 2.8% (1.3 p.p.)	

Notes: This table reports the simulation results for a rise in the transaction tax rate when the gap between the average mortgage and the marginal mortgage interest rate is calibrated to be 3%. The responses of variables are reported as log differences.

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