Search and Matching with Behavioral Agents in Housing Markets

A two-paper tour of the toolkit, the theory, and what's left to do.

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Today's lecture: two papers, one mechanism

- Building on Lu Han's morning talk on search-and-matching for affordability, we push the framework in two directions:
  - **(I)** *In Search of the Matching Function* – BBR&S (2024). The matching technology as an empirical object.
  - **(II)** *Behavioral Lock-In* – BRST (2026). That technology plugged into a heterogeneous-agent model with loss-averse sellers.
- **The mechanism**: reference dependence raises sellers' WTA; the wedge with buyers' WTP widens; *quantities absorb what prices would otherwise absorb*.
- **Aim**: estimate the matching function $\rightarrow$ embed behavioural preferences $\rightarrow$ solve the heterogeneous-agent model $\rightarrow$ draw policy conclusions.

Why behavioural agents in housing markets?

- Large literature: the neoclassical characterisation of households is imperfect.
  (DellaVigna 2018; Gomes-Haliassos-Ramadorai 2021).
- **Heterogeneous agents matter**: aggregate outcomes depend on the cross-sectional distribution of micro states. Non-linear decision rules amplify through prices and matching.
  (Krusell-Smith 1998; Kaplan-Violante 2014; Maxted 2024).
- **Behavioural frictions generate heterogeneity persistently**. Reference dependence anchors each agent to a path-dependent nominal benchmark; the cross-section evolves slowly with realised transactions, so small shocks have long-lived aggregate effects. (Genesove-Mayer 2001; Bracke-Tenreyro 2021; Andersen et al. 2022).
- Housing is the natural laboratory: large stakes, granular micro data, central to policy.

Three frictions, and why they have to be modelled together

- Three frictions, three literatures:
  - **Search**: meetings, processing, match quality. (Wheaton 1990; Piazzesi-Schneider 2009; Ngai-Tenreyro 2014).
  - **Financial**: home equity, down payments, mortgage lock. (Stein 1995; Ortalo-Magné & Rady 2006).
  - **Behavioural**: nominal anchoring on the price paid. (Genesove-Mayer 2001; Andersen et al. 2022).
- **Why model them jointly?**
  - Reference dependence *operates through* the transaction probability – without an explicit matching function you have no language for what loss aversion does to volumes.
  - The matching function is shaped by seller pricing – which depends on (r_i, m_{it}).
  - Empirically the three frictions need to be *separated*: behavioural margin survives in the non-mortgaged sample (Slides 13–15).

Roadmap

Part I: The matching function in housing markets

Part II: Empirical foundations for behavioural lock-in

Part III: A heterogeneous-agent model with reference-dependent sellers

Part IV: Applications – cycles, hysteresis, fiscal policy

Conclusion

Why a careful matching function matters

- Most market settings require **counterparties** on the demand and supply side to find each other.
- The aggregate **matching function** is the workhorse representation:

$$V_{it} = \mathcal{M}(D_{it}, S_{it})$$

  - Cobb-Douglas vs. exponential vs. Poisson vs. CES – consequential for everything that follows.
- For housing models the choice matters quantitatively:
  - Determines transaction probability $\alpha_t(\cdot)$ that sellers face.
  - Determines the equilibrium response of *volumes* to shocks.
  - Determines how policy changes (taxes, monetary shocks) propagate through the cross-section.
- Without firm *empirical* grounding, the matching function is a free parameter.

Tracing the life cycle of a transaction

- Granular UK data lets us observe the full pipeline:
  - Listings S (Rightmove); searchers D (clicks/IP-level); meetings M (contact requests); transactions V (Land Registry).

Search and transaction activity per listing (S), per month

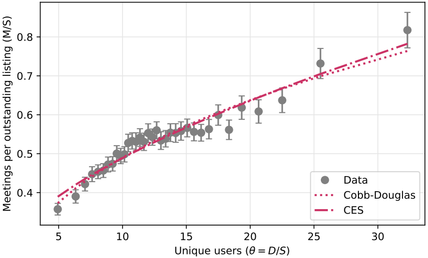
	Sales	Rentals
Unique searchers ($\theta = D/S$)	13	15
Physical meeting requests (M/S)	0.54	3.08
Number of listing price revisions	0.08	0.10
Average listing price revision	-3%	-1%
Transaction probability (V/S)	0.09	0.20
Median time-on-market	6 months	2 months

- 357/374 UK local authorities; 2019–2022 (48 months); ~ 9.4M listings.

Matching function in the data: Cobb-Douglas and CES are observationally close

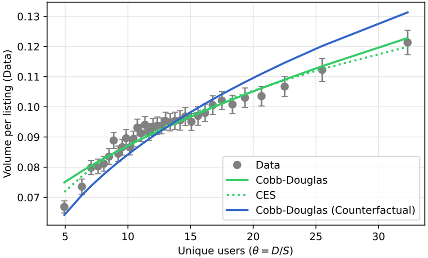
Meeting intensity M/S

$$M_{it}/S_{it} = \mu\theta_{it}^{\alpha}$$



Transaction probability V/S

$$V_{it}/S_{it} = \mu\theta_{it}^{\alpha}$$



- Estimated at LAD (i) × month (t) level. Implied elasticities: $\alpha = 0.35$ (meetings), $\alpha = 0.28$ (transactions).
- Cobb-Douglas and CES both fit the conditional mean. **Constant returns to scale**, demonstrated next.
- Exponential matching functions are clearly rejected by the level data (see appendix).

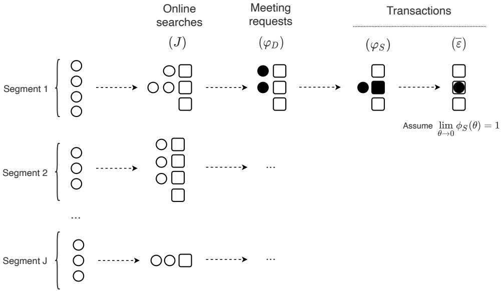
Returns to scale: constant at the transaction stage, in both segments

$$\ln Y_{it} = \mu + \alpha_D \ln D_{it} + \alpha_S \ln S_{it} + \epsilon_{it}.$$

	Properties **for sale**			Properties **for rent**		
Y_{it} :	Searches	Meetings	Transactions	Searches	Meetings	Transactions
Demand (α_D)	0.948***	0.397***	0.272***	0.870***	0.806***	0.349***
	(0.013)	(0.038)	(0.021)	(0.020)	(0.035)	(0.025)
Supply (α_S)	0.296***	0.666***	0.721***	0.300***	0.321***	0.617***
	(0.015)	(0.041)	(0.024)	(0.032)	(0.014)	(0.023)
$\alpha_D + \alpha_S$	1.243	1.064	0.993	1.169	1.126	0.965
H_0: CRS (p-Value)	0.00	0.04	0.70	0.49	0.00	0.00
Obs.	16,269	16,269	16,269	16,262	16,262	16,262
R^2	0.936	0.593	0.685	0.964	0.796	0.851

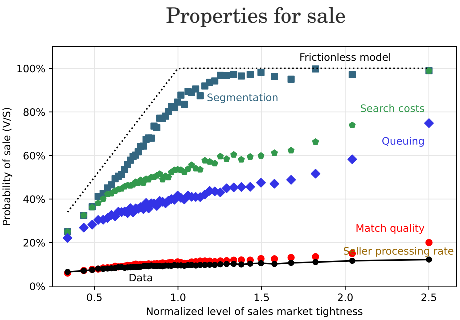
- **Cobb-Douglas with CRS at the transaction stage**, in both sales and rentals.
- Increasing returns at earlier stages (search, meetings): congestion "builds up" down the funnel.

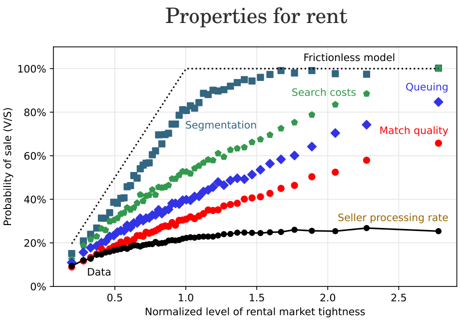
Where does congestion come from? Structural decomposition



- Estimate a structural model with: preference segmentation J, buyer meeting rate ϕ_D, seller processing rate ϕ_S, match quality $\bar{\varepsilon}$.
- Decomposes the elasticity into interpretable behavioural primitives.

Decomposing congestion: search costs and matching quality dominate





- **Sales**: ~30% search costs; ~42% **match quality** (idiosyncratic taste); rest preference segmentation.
- **Rentals**: ~30% search costs; ~32% **landlord processing rate**; rest match quality.
- **Take-away for Part II**: micro-founded Cobb-Douglas, $\chi(q) = \bar{\chi}\, q^{\upsilon}$ with $\upsilon \approx 0.57$, is the matching function we will plug in.

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What we do (Paper II) – and three pieces of vocabulary

- **Paper loss**: $\hat{G}_{it} \equiv \log(\hat{P}_{it}) - \log(R_i) < 0$. $\hat{P}_{it}$ current hedonic value, R_i purchase price.
- **Listing premium** $\ell \equiv$ listing price / hedonic value -1. **"Hockey stick"**: ℓ rises sharply once $\hat{G} < 0$.
- **Behavioural lock-in**: anchoring on R_i raises sellers' WTA above buyers' WTP; the wedge depresses transaction probability rather than the price.

1. **New facts** (UK admin data 2010–2024): bunching in realised gains; hockey-stick listing premium; cross-region prediction of P–V comovement and volume volatility from the loss share.
2. **Equilibrium model**: heterogeneous-agent search-and-matching with reference-dependent sellers, down-payment constraints, BBR&S matching technology.
3. **Policy applications**: *hysteresis* – temporary shocks leave permanent imprints; *tax distortions scale with the loss share* – a national tax is a regional policy, and a property tax that is neutral in the frictionless benchmark becomes distortionary in the short run.

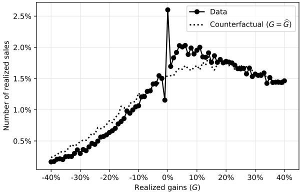
Data

- HM Land Registry deed-level records.
  - 28 million transactions for the period 1995–2024.
- Royal Mail residential address data.
  - Covers UK housing stock: 27.3 million unique postal units.
- Listings of properties for sale and for rent, from Rightmove.com.
  - 23.3 million listings, 357/374 UK local authorities, 2010–2024.
  - 81% of Land Registry transactions match to a corresponding listing (2024).
- Online search behaviour.
  - 6 billion click-level events; 20 million meeting requests.
- Bank of England mortgage data at the loan level.
  - Universe of mortgage contracts 2015–2024 (PSD007).

Micro Fact 1: Realised nominal gains bunch at zero

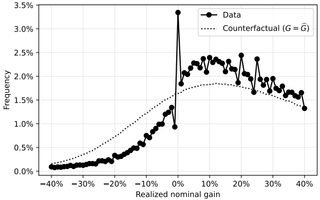
- Realised gain $\equiv \frac{\text{Transaction price}}{\text{Initial purchase price}} - 1$. (Reference point $\equiv$ initial purchase price.)

Denmark

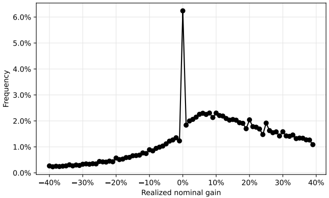


Source: Andersen et al. (2022)

U.K.



U.S.A.



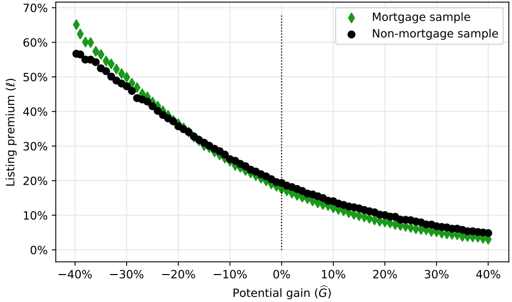
Source: Badarinza et al. (2026)

- Same pattern across three economies, three datasets. Sellers *refuse to realise nominal losses*.
- Robust to standard alternatives: not real-return rounding (kink doesn't move with inflation); not taxes (UK has no CGT on primary residence yet shows the kink); not liquidity (pattern survives in the non-mortgaged sample, next slide).

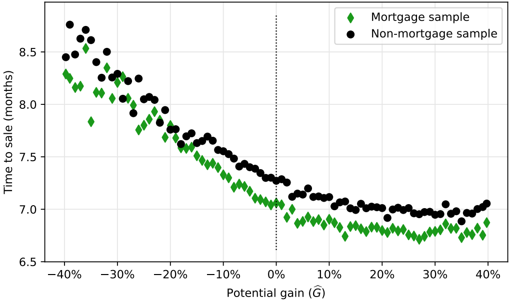
Micro Fact 2: Listing premium "hockey stick" and time-on-market

- Potential gain $\widehat{G} \equiv$ estimated nominal price appreciation since purchase.
- Listing premium $\ell \equiv$ listing price / hedonic value $- 1$ (at initial listing).

Ex-ante listing behaviour



Average time to sale

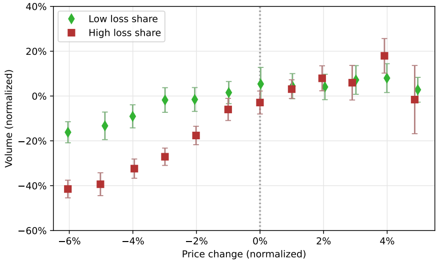


- Loss-domain sellers list aggressively above hedonic value; sit on the market much longer.
- Pattern is preserved (and *stronger*) for non-mortgaged sellers $\Rightarrow$ not driven by financial frictions alone.

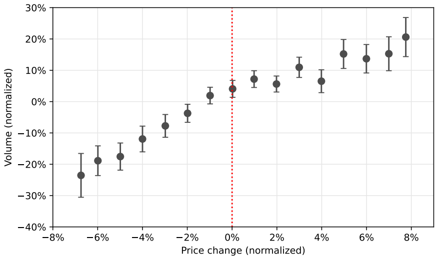
Macro motivation: paper losses, prices, volumes

- Calculate prices and volumes at the ITL2 level (35 UK regions, 50 US states), 2010–2024.
- Split regions by share of homeowners with paper losses (top vs. bottom 25%).

U.K. (Land Registry)



U.S.A. (Zillow)

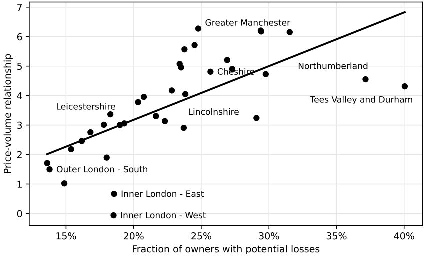


- Year-on-year price changes and volumes, less location fixed effects.
- **High loss-share regions are very different** in their price–volume joint dynamics.

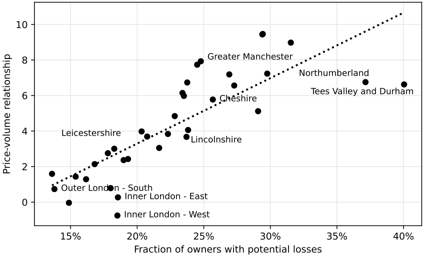
Cross-region scatter: P–V comovement depends on the loss share

- Compute share of sellers with paper losses for each ITL2 region. Regress monthly log volume on YoY price change within region.

Full sample



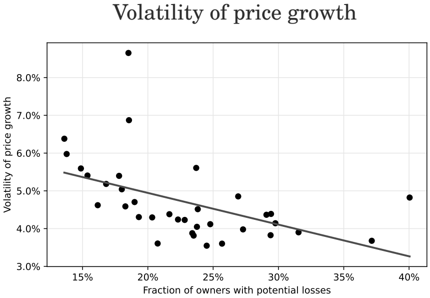
Non-mortgaged sample

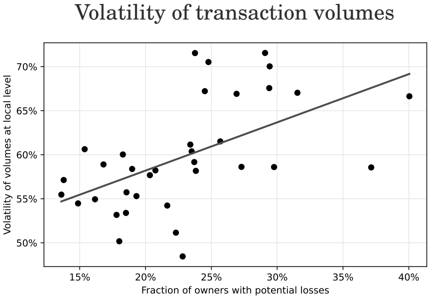


- Higher loss share $\Rightarrow$ *stronger* positive P–V comovement.
- **Survives in the non-mortgaged subsample** $\Rightarrow$ not just a financial-friction story.

Quantities react, rather than prices

- Higher paper-loss share is associated with *higher volatility of transaction volumes*, not prices.





- Standard deviations of YoY volumes and price growth, 2010–2024, by ITL2 region.
- **This is the empirical signature of behavioural lock-in** – the model below has to deliver it.

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Model overview

- Discrete time, period = 6 months, $\beta < 1$. Unit mass of houses; homeowners indexed by i with state (r_i, m_{it}): **reference price** (log purchase price) and mortgage balance.
- Homeowners draw moving shock θ_{it} with prob. ρ; choose whether to list, set asking price.
- Constant mass N_B of buyers; meet sellers via the BBR&S **Cobb-Douglas matching function** $\chi(q_t) = \bar{\chi}\, q_t^{\upsilon}$, $q_t = N_B/N_{St}$.
- Buyers draw taste ε_{jt} and mortgage $m_{j,t+1}$; accept or reject.
- **Crucial modelling choice**: the full distribution $f_t(r, m)$ is the aggregate state. Each agent's policy depends on f_t; f_t depends on policies. A slow-moving distribution of reference points encodes the history of past shocks – this is what makes hysteresis possible.

Seller's problem (i): state, decision, utility

- State (r_i, m_{it}): reference price r_i fixed at purchase; mortgage m_{it} amortises deterministically.
- Homeowner draws moving opportunity $\theta_{it} \sim F_\theta$ and chooses among three actions:
  1. Don't list – continuation value $\beta \mathbb{E}_t V^h_{t+1}$.
  2. List at p_{it}, succeed w.p. $\alpha_t(p_{it})$, become a buyer.
  3. List at p_{it}, fail w.p. $1 - \alpha_t(p_{it})$, pay cost ϕ, continue.
- **Utility upon sale carries the behavioural primitive**:

$$U(p_{it}, r_i, m_{it}) = p_{it} + \underbrace{\eta_-(p_{it} - r_i)_- + \eta_+(p_{it} - r_i)_+}_{\text{reference dependence}} - \underbrace{\mu\big[(\gamma - (p_{it} - m_{it}))_+\big]^2}_{\text{down-payment penalty}}.$$

- Piecewise-linear in $(p - r)$ with $\eta_- \gg \eta_+$ – fits the hockey stick, avoids full K-R structure.

Seller's problem (ii): Bellman, threshold rule, real options

- Bellman equation:

$$V_t^h(\theta_{it}, r_i, m_{it}) = \max\Big\{ \max_{p_{it}} \underbrace{\alpha_t(p_{it})\big[U(\cdot) + \theta_{it} + \beta\mathbb{E}_t V_{t+1}^b\big]}_{\text{listing success}} + \underbrace{(1-\alpha_t(p_{it}))\beta\mathbb{E}_t V_{t+1}^h}_{\text{listing failure}} - \phi,\ \underbrace{\beta\mathbb{E}_t V_{t+1}^h}_{\text{no listing}} \Big\} + u_t.$$

- **Listing is a threshold rule** – a real-options problem. List iff $\theta_{it} \geq \theta_t^*(r_i, m_{it})$:

$$\theta_{it}^*(r_i, m_{it}) = \frac{\phi}{\alpha_t(p_{it}^*)} - \big[U(p_{it}^*, \cdot) + \beta\mathbb{E}_t V_{t+1}^b - \beta\mathbb{E}_t V_{t+1}^h(\cdot)\big].$$

- **Two unknowns per state** (p^*, θ^*), jointly determined: price-setting FOC trades realised gain off against transaction probability; θ^* depends on $\alpha_t(p^*)$, which depends on θ^*.
- Reference dependence enters *twice*: directly via U (the loss term) and indirectly via V_{t+1}^h – the homeowner anticipates being locked in tomorrow.

Buyers and equilibrium

- Upon meeting, buyer j draws taste ε_{jt} and mortgage $m_{j,t+1}$:
  $\max\left\{\mathbb{E}_t V^h_{t+1}(p_{it}, m_{j,t+1}) + \varepsilon_{jt} - p_{it},\ \beta\mathbb{E}_t V^b_{t+1}\right\}$.
  Threshold: $\varepsilon^*_t(p) = \beta\mathbb{E}_t V^b_{t+1} - \left[\beta\mathbb{E}_t V^h_{t+1}(p, m) - p\right]$.
- **Transaction probability** faced by sellers:

$$\underbrace{\alpha_t(p)}_{\text{P(transact)}} = \underbrace{\chi(q_t)}_{\text{P(meet) – BBR\&S}} \times \underbrace{[1 - F_\varepsilon(\varepsilon^*_t(p))]}_{\text{P(accept — meet)}}.$$

- **Distribution evolves endogenously**:

$$f_{t+1}(r, m') = f_t(r, m)\left[1 - \rho\int_{\theta^*}^{\infty}\alpha_t(p_t(\theta))\,dF_\theta\right] + N_{St}\,\omega_t(r)\,\alpha_t(r)\,f_m(m').$$

  In steady state $f_t = f_{t+1}$.

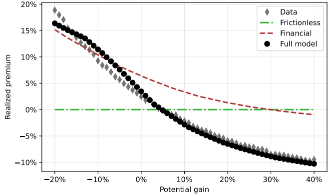
Calibration

Parameter		Value	Target / Source
Externally fixed			
Time discount	β	0.990	Period $=$ 6 months
Matching elasticity	υ	0.571	**Badarinza et al. (2024)**
Market tightness	q	3.229	**Badarinza et al. (2024)**
Mortgage amortisation	δ_m	0.018	BoE mortgage data
Down-payment threshold	γ	0.300	BoE schedule
Structurally estimated (SMM on micro moments)			
Loss aversion / gain	η_-, η_+	1.0, 0.01	Hockey-stick slope
Down-payment penalty	μ	20.00	LTV-listing-premium gradient
Flow utility / mob. shock / taste shock / listing cost			Listing prob., TOM, $\alpha(\ell)$

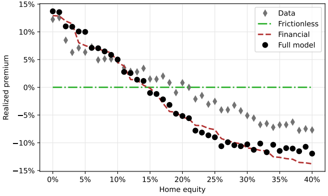
- Matching function from Paper I plugged in directly. Behavioural parameters identified from micro cross-sectional patterns; aggregate fit is then *out-of-sample*.

Calibration: fit to micro moments

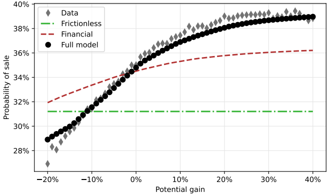
Realised premium
(by potential gain)



Realised premium
(by home equity)



Probability of sale



- Model jointly fits the loss-domain “hockey stick”, the home-equity gradient, and the concave demand profile.
- **Two behavioural parameters** (η_-, μ) plus the matching function deliver the micro pattern.

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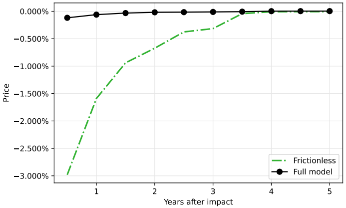
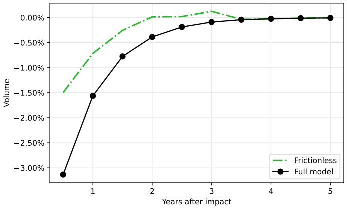
Price and volume responses to shocks

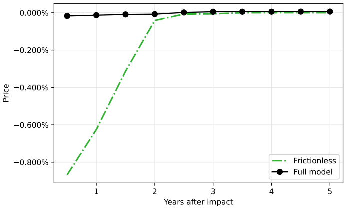
Prices | Volumes

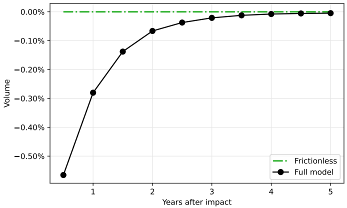
Demand shock (ε)





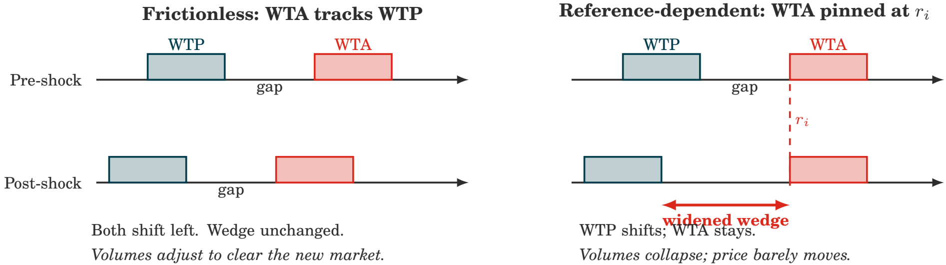
Flow utility (u)





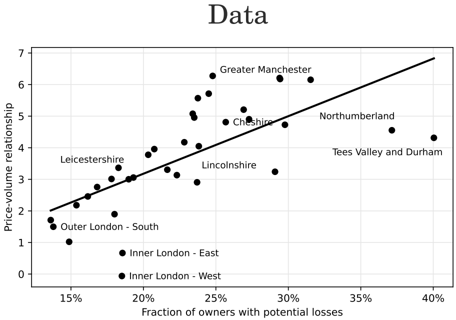
Note: 5% temporary decrease in average ε (top); 0.5% temporary decrease in u (bottom). Decay rate 0.5 per 6-month period.

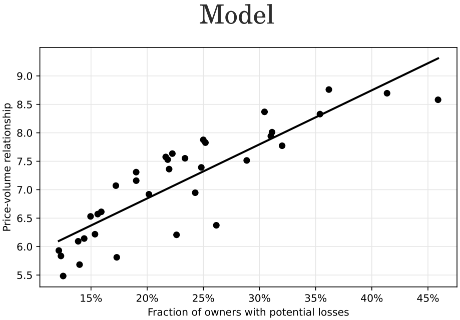
The transmission mechanism: behavioural lock-in, picture-form



- **Individual mechanism**: r_i pins WTA from below; loss aversion makes the lower tail of the seller's reservation price distribution sticky.
- **Aggregate consequence**: trades that would have happened at the new lower price don't happen. Quantitatively, a mobility shock $\sim 5\times$ larger is needed to deliver the frictionless impact.

Untargeted moment: P–V comovement, data vs. model



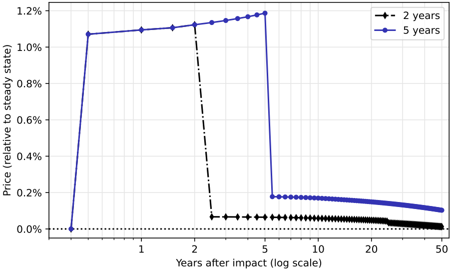


- Model-implied P–V relationship: ratio of initial volume to initial price response to a demand shock, varying the loss share.
- **Untargeted**: the model reproduces the cross-region P–V slope and its dependence on the loss share.

Hysteresis: temporary shocks leave permanent imprints

Average transaction price

(Reversal in period n)



- **Shock sequence**: stationary equilibrium; unanticipated permanent valuation shock at $t = 0$, exactly reversed at $t = n$.
- **Mechanism**: reference points re-anchor on realised transaction prices; reversal of fundamentals leaves a residual displacement.
- **Quantitatively**: after a 5-year shock that fully reverses, only 85% of the initial price impact is undone.

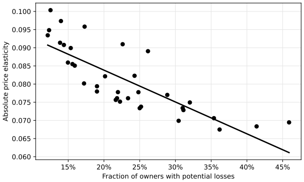
Fiscal policy: setup

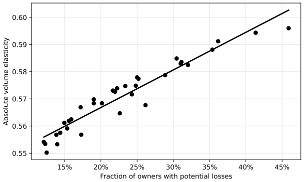
- **Transaction tax** $\tau^b = 3.3\%$ (UK avg. stamp duty). Paid by buyer; wedge on buyer's valuation: $\max\left\{\mathbb{E}_t V^h_{t+1} + \varepsilon_{jt} - p_{it} - \tau^b,\ \beta \mathbb{E}_t V^b_{t+1}\right\}$.
- **Property tax** $\tau^h = 0.9\%$ (UK avg. council tax). Wedge on flow utility: $u_t \mapsto u_t - \tau^h$.
- **Conventional view** (Mirrlees 2012; Saez-Zucman 2019): stock-based taxes are more efficient – they don't distort the moving margin, transaction taxes do.
- **What our model adds**:
  - Behavioural and financial frictions *amplify* the distortions of the transaction tax.
  - The property tax – neutral in the frictionless benchmark – is distortionary in the short run as reference points adjust slowly. The inefficiency fades; in steady state, behavioural $\rightarrow$ frictionless. **But the horizon is very long.**
  - Distortions **scale with the loss share** – a national tax is a regional policy.

The cross-section: a national tax is a regional policy

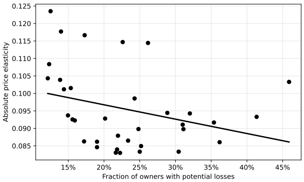
	Price impact	Volume impact

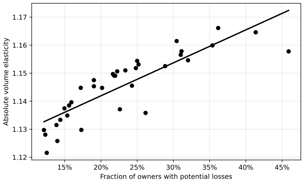
Transaction tax





Property tax





- Tax effects plotted against ITL2 loss share. **High loss-share regions absorb the same national tax very differently from low loss-share regions**.
- **Implication for empirical work**: tax reform studies that pool across regions confound a behavioural mechanism with a quantitative one.

Roadmap

Part I: The matching function in housing markets

Part II: Empirical foundations for behavioural lock-in

Part III: A heterogeneous-agent model with reference-dependent sellers

Part IV: Applications – cycles, hysteresis, fiscal policy

Conclusion

What we've covered

- **The matching function is not a free parameter**. Granular data on listings, searches and meetings $\Rightarrow$ Cobb-Douglas with CRS, $\upsilon \approx 0.57$.
- **A new aggregate statistic**: the paper-loss share. Predicts P–V comovement, volume volatility, response to shocks and to taxes.
- **Search-and-matching with reference-dependent sellers** reproduces these patterns and delivers two distinctive results:
  - *Behavioural lock-in*: quantities react more, prices react less.
  - *Behavioural hysteresis*: temporary shocks leave permanent imprints.
- **Tax policy**: behavioural frictions amplify transaction-tax distortions and make property taxes distortionary in the (long) short run. National taxes have very different effects across regions, scaling with the loss share.

Open agenda: projects you could start tomorrow

- **When is the reference point reset?** Model assumes $r_i =$ purchase price. Mortgage refinancing changes LTV without a transaction. Use BoE PSD007 + Land Registry; identification from refinancing timing relative to listing.
- **Heterogeneous updating speed**. Estimate $r_{it} = \lambda_i R_i + (1 - \lambda_i)\hat{P}_{it}$ and let λ_i vary with experience, age, sophistication.
- **Macroprudential lock-in**. Counter-cyclical LTV caps tighten in booms. Do they accidentally cement reference points by blocking the marginal seller?
- **Climate valuation shocks and hysteresis**. Coastal flood reassessments are large, persistent, region-specific shocks. Does reference dependence slow the residential adjustment to climate risk?
- **Mortgage lock-in vs. behavioural lock-in**. US fixed-rate market generates a parallel "locked-in" phenomenon for very different reasons. The two mechanisms compete for the same volume reduction – decompose them.
- **The rental market**. Same matching technology, different agents (landlords are firms). Is there an analogous behavioural margin? Hypothesis: it disappears.

Thank you.

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Appendix follows – pulled up on request during Q&A.

A.1 Targeted moments and model fit

Moment	Data	Model
Unconditional		
Price (normalisation)	1.00	1.01
Listing premium (mean)	0.083	0.093
Listing probability (per period)	0.025	0.025
Demand α at $\ell = 0.20$	0.30	0.22
Listing-premium gradients (cross-section)		
Home equity, left slope ($\widehat{H} \leq 0.20$)	-0.130	-0.140
Home equity, right slope ($\widehat{H} > 0.20$)	-0.098	-0.092
Potential gain, left slope ($\widehat{G} \leq 0$)	-1.08	-0.29
Potential gain, right slope ($\widehat{G} > 0$)	-0.36	-0.27

- Model captures unconditional levels and qualitative slopes in both home-equity and gain/loss domains. **Hardest moment**: loss-domain slope of the gain hockey stick – model captures sign and kink, under-predicts magnitude. Aggregate moments (P–V, volume volatility) are *not targeted*; they are the out-of-sample test.

A.2 IV identification: listing premium → time-on-market

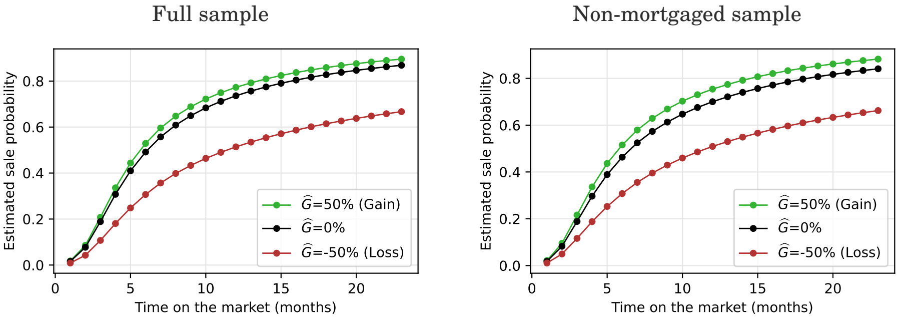
- Concern: listing premium is endogenous (depends on unobserved seller characteristics). Use **average potential loss/gain** in the MSOA as instruments.

	First stage		Time on market	Sale indicator
	OLS	OLS	2SLS	2SLS
Average listing premium			9.552***	−0.283***
			(1.538)	(0.044)
Average potential loss	0.257***	0.255***		
	(0.014)	(0.014)		
Average potential gain	−0.008***	−0.008***		
	(0.002)	(0.002)		
Average constrained LTV		0.016***	1.189***	0.017***
		(0.004)	(0.164)	(0.004)
MSOA × year FE	Yes	Yes	Yes	Yes
N	57,874	57,874	57,873	57,874
R^2	0.848	0.849	0.641	0.806
First-stage F			1,092	1,600

- Standard errors clustered at ITL2; instruments are average potential loss ($-\widehat{G}$ if $\widehat{G} < 0$), average potential gain, and excess LTV.
- **2SLS magnitudes are larger than OLS** – consistent with classical attenuation. F-stats well above conventional thresholds.

A.3 Cox proportional hazards: alternative TOM specification

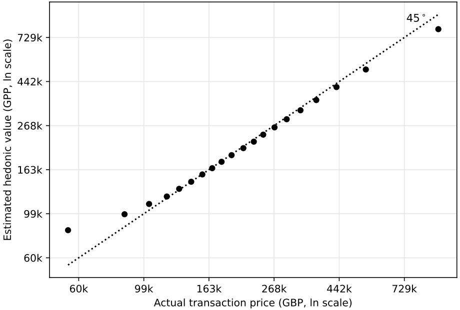
- Estimate $h(t) = H(t)\, e^{\beta \mathbf{X}}$ with parametric Weibull baseline. Separately estimated coefficients in loss ($\widehat{G} < 0$) and gain ($\widehat{G} \geq 0$) domains.



- Hazard of sale is sharply lower for sellers in the loss domain at every horizon.
- Pattern survives in non-mortgaged sample $\Rightarrow$ not a financial-friction artefact. Same conclusion as the binscatter in the body, with parametric standard errors.

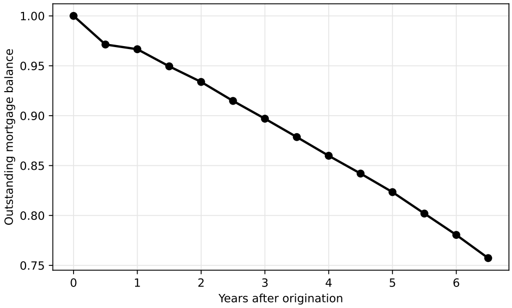
A.4 Hedonic price model: how we compute $\widehat{P}$

- For each property and date, estimate a hedonic regression on *out-of-sample* transactions in the same area (excludes the listed property's own transactions to avoid mechanical fit).
- Controls: bedrooms, bathrooms, type, tenure, local authority $\times$ year FE, building period, EPC rating, area. In-sample $R^2 \approx 0.87$.
- **Robustness**: LASSO/Ridge shrinkage, time-varying coefficients, including/excluding development properties – none move qualitative results.



A.5 Mortgage amortisation: where $\delta_m = 0.018$ comes from

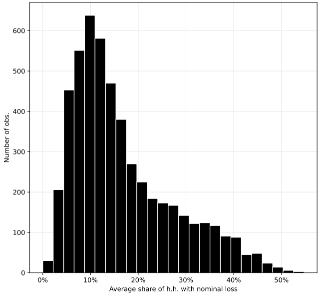
- Bank of England PSD007 panel: cohort of mortgages originated 2015H1, tracked half-yearly to maturity or refinancing.
- Estimate $b_{it} = \sum_t \mathbb{D}_t + \varepsilon_{it}$, where $b_{it} = l_{it}/l_{i,\text{2015H1}}$ is the outstanding balance ratio.
- The half-yearly coefficient $\widehat{\mathbb{D}}_t$ traces out the average amortisation profile; deterministic schedule fits well.



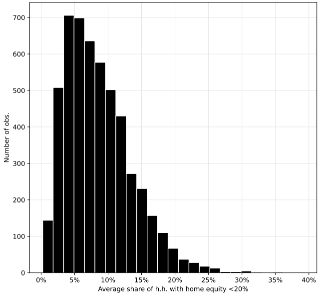
- Implied semi-annual amortisation rate: $\delta_m \approx 1.8\%$ on the outstanding balance.
- **Refinancing** and over-payments add idiosyncratic variation we abstract from – this is a natural extension (see open agenda, Slide 37).

A.6 Distributional anatomy: paper losses, home equity, LTV

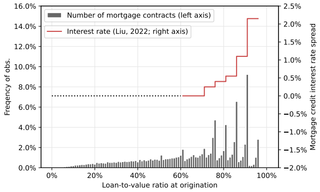
Paper losses $\widehat{G}$



Home equity $\widehat{H}$



Origination LTV



- Both behavioural and financial frictions have non-trivial mass in the data: $\sim$22% of homeowners hold paper losses on average; $\sim$15% have home equity below 20%.
- **The two distributions are imperfectly correlated** – which is what allows us to separately identify η_- and μ in the calibration. Sellers near zero gain and high equity reveal η_-; sellers near low equity and zero gain reveal μ.

A.7 Surplus decomposition: where the welfare goes

	Frictionless	Full model
Buyer surplus	0.0224	0.0200
Seller surplus	0.0569	0.0577
Listing premium	−0.0141	−0.0103
Mobility (θ)	0.0710	0.0699
Gains/Losses	—	−0.0017
Financial penalty	—	−0.0001
Total surplus	**0.0793**	**0.0777**

- Surplus expressed as a fraction of average house value (present value).
- Behavioural frictions cost ∼2% of total surplus – not enormous, but **the redistribution between buyers and sellers is substantial**: buyers lose 11%, sellers gain (slightly).
- Q&A: one might expect buyers to gain from frictions that constrain sellers. Why don't they? Because rational buyers anticipate that they will later be locked-in sellers, and bid less.

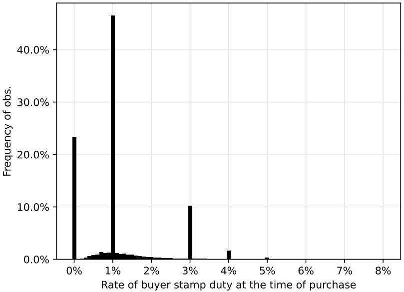
A.8 Why piecewise-linear utility, not Kőszegi-Rabin?

- **Kőszegi-Rabin (2006)**: reference point is the rational expectation of consumption – forward-looking and endogenous.
- **Our specification**: $r_i =$ purchase price, fixed at acquisition; piecewise-linear loss/gain utility around r_i.
- **Why the simpler choice?**
  - *Empirical hook*: bunching, hockey stick, and TOM patterns are sharply located at the realised purchase price. K-R reference points are not directly observed and require auxiliary structure.
  - *Identification*: with $r_i = R_i$ we sort on $\widehat{G}$ and read off η_- from the kink slope. K-R requires solving a fixed-point on beliefs to recover the reference distribution.
  - *Prior evidence*: Genesove-Mayer (2001), Bracke-Tenreyro (2021), Andersen et al. (2022) all use a fixed-purchase-price reference; K-R has been harder to pin down in housing.
- **What we give up**: heterogeneity in updating speed; reference revision after a shock. Slide 37 sketches one way to put updating speed back in.

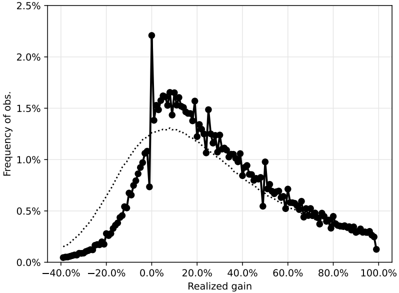
A.9 Stamp duty: a bunching test of the model

- Pre-2014 UK stamp duty schedule had a **notch** at £250k (the rate jumped from 1% to 3%); post-reform there is a *kink*. Under the model, the bunching mass at £250k should be *larger in regions with a higher loss share* – behavioural lock-in amplifies the price-setting response to taxes.

2013 (notch regime)

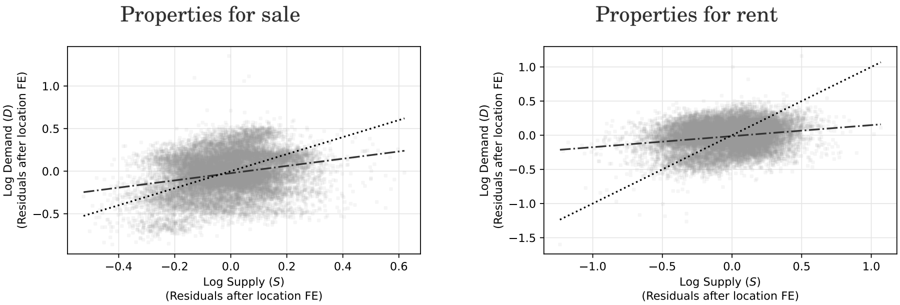


2016 (kink regime)



- Cross-region bunching mass at £250k is positively related to the regional loss share, conditional on tax-base composition.
- **This is a quasi-experimental cross-check** on the model's tax channel – a moment we did *not* use in calibration.

A.10 The Beveridge curve in housing – BBR&S



- Cross-region scatter of vacancies (listings) vs. "unemployment" (un-met demand). Same shape as labour-market Beveridge curve.
- Consistent with Gabrovski-Ortego-Marti (2019) and Piazzesi-Schneider-Stroebel (2020). Validates a CRS Cobb-Douglas matching technology and rules out pure stock-flow or pure coordination models.
- Used in BBR&S as one of the orthogonal pieces of evidence for the matching function specification we plug into Paper II.

A.11 Cross-market search: sales and rental segments are linked

	Within-market		Cross-market	
Dependent: V/S (sales)	(1)	(2)	(3)	(4)
Sales tightness $\theta_S = D_S/S_S$	0.316***	0.202***	0.201***	0.185***
	(0.029)	(0.032)	(0.031)	(0.032)
Search effort I/D		−0.552***	−0.503***	−0.500***
		(0.052)	(0.054)	(0.053)
Number of revisions per listing			−0.073***	−0.069***
			(0.011)	(0.011)
Rental tightness $\theta_L = D_L/S_L$				0.037***
				(0.013)
Location FE; Month FE	Yes	Yes	Yes	Yes
R^2	0.758	0.763	0.764	0.765

- Rental-market tightness has *positive* explanatory power for sales market transaction probability, conditional on within-market tightness.
- Mechanism: tight rental markets push marginal renters into ownership; spillovers into sales-market matching.
- **In Paper II we shut this down** (single-segment model); a natural extension is to embed the cross-market matching technology of BBR&S in the heterogeneous-agent equilibrium.

A.12 Sensitivity to behavioural parameters

- **η_- (loss aversion)**: under-shooting halves volume volatility; over-shooting flips the P–V correlation negative. Calibrated value sits at $\eta_- = 1$, the slope implied by Andersen et al. (2022).
- **μ (down-payment penalty)**: principally determines the home-equity gradient of the listing premium; identified independently of η_- because it bites at low $\widehat{H}$, not at $\widehat{G} \approx 0$.
- **β (discount factor)**: matters for how forward-looking sellers anticipate future re-entry as buyers. At higher β, sellers raise WTA further in response to transaction-tax wedges – magnifying short-run tax distortions but not changing the steady-state convergence.
- **υ (matching elasticity)**: changing from BBR&S value 0.57 to alternative estimates in the literature (range 0.3–0.7) changes the volume IRF magnitudes by $\sim$15%, but does not flip any qualitative result. The matching function is necessary but the *exact* value is not load-bearing.