Very Long-Run Discount Rates

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Empirical Household Finance PhD Class

Discounting the Very Long Run

- Long-run discount rates play crucial role in many economic questions
  - Climate change: trade-off immediate costs and very distant benefits
- Little direct empirical evidence on very long-run discount rates
  - OMB recommends using wide range of discount rates (1% - 7%) for "intergenerational" projects
  - While markets provide a reference for discounting within a generation, "for extremely long time periods no comparable private rates exist."
- Empirical Challenge:
  - Would like to observe prices of claims to cash flows at all maturities
  - We generally only observe:
    - Infinite maturity assets: equities
    - Relatively short maturity assets: bonds or dividend strips

Our Approach

- Exploit a feature of housing markets in the UK and Singapore to provide *direct estimates of very long-run discount rates*
- Residential property ownership:
  - **Freeholds:** Permanent ownership (as in US)
  - **Leaseholds:** Temporary ownership for varying tenure (99 - 999 years)
  - Key: Prepaid; Liquid secondary market for leaseholds; similar properties; Few contractual restrictions on leaseholders

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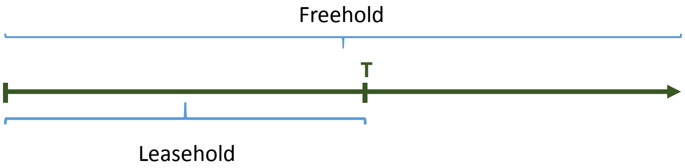

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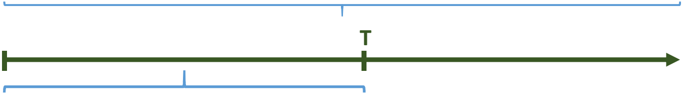
Freehold: P = $\frac{D}{r-g}$



Leasehold: $P^T = \frac{D}{r-g}(1 - e^{-(r-g)T})$

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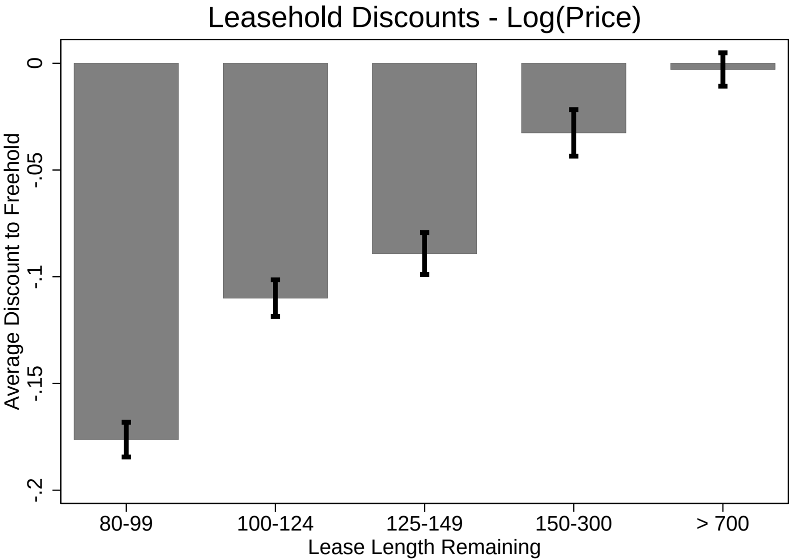
$$Disc^{100} \equiv \frac{P^{100}}{P} - 1 = -e^{-(0.065-0.007)100} = -0.3\%$$

Contribution

- QJE paper:
  - Construct dataset of all freehold and leasehold transactions
  - Estimate long-run discount rates using hedonic regressions
- This paper:
  - Compute average returns to housing (6-8%) and rent growth (0.5%)
  - Estimate the shape of the term structure of discount rates
  - Learn about long-run discount rates (risk free and risk premia)
  - Discuss implications for public and environmental economics

Preview of Results



Results Preview - Average and Long-run Discount Rates

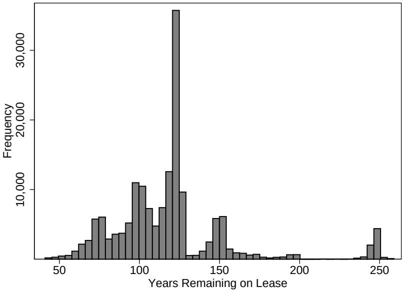
- *Jointly*, high average return and large discounts for long-term leases:
  - **Average return uninformative about long-run discount rates**
    - long-run discount rates
    - **Downward sloping** term structure of discount rates
- Long-run housing is risky:
  - Low long-run risk-free rate
  - Low long-run price of risk
- Implications for climate change
  - High willingness to invest in **sure** projects
  - More tolerance for risk
  - Caveat: systematic risks exposures of housing and climate change

Roadmap

- Empirical Analysis
  - Leasehold Discounts: UK
  - Leasehold Discounts: Singapore
  - Expected Returns and Risk
- Constant-discounts Benchmark
- Implications for Climate Change and Intergenerational Policies

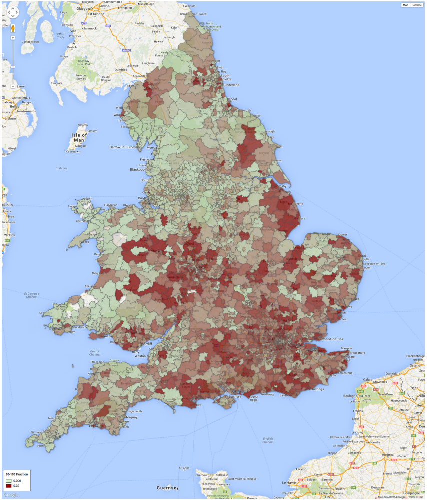
Data for the UK

- Administrative data on all transactions and lease terms since 2004
  - 1.3 million transactions for flats
  - 8% Freeholds; Initial lease length distributed between 99 - 999 years
- Property characteristics, listings and rental data from Rightmove.co.uk

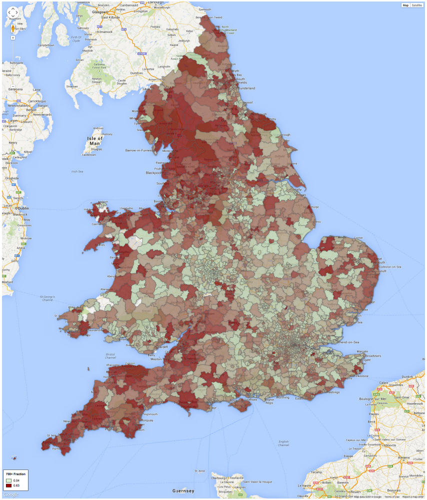


Data for the UK

Geographic Distribution of Flats



(a) 80-100 years leaseholds



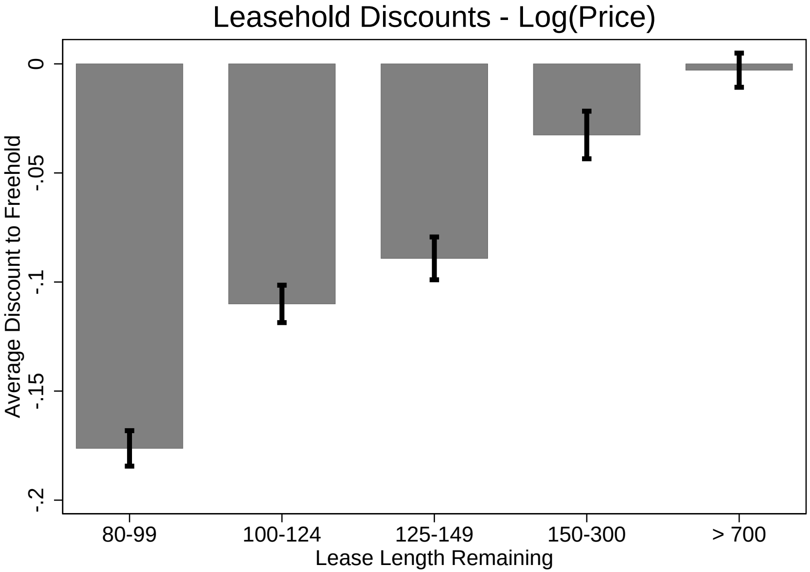
(b) 700+ years leaseholds

Hedonic Regressions: Specification

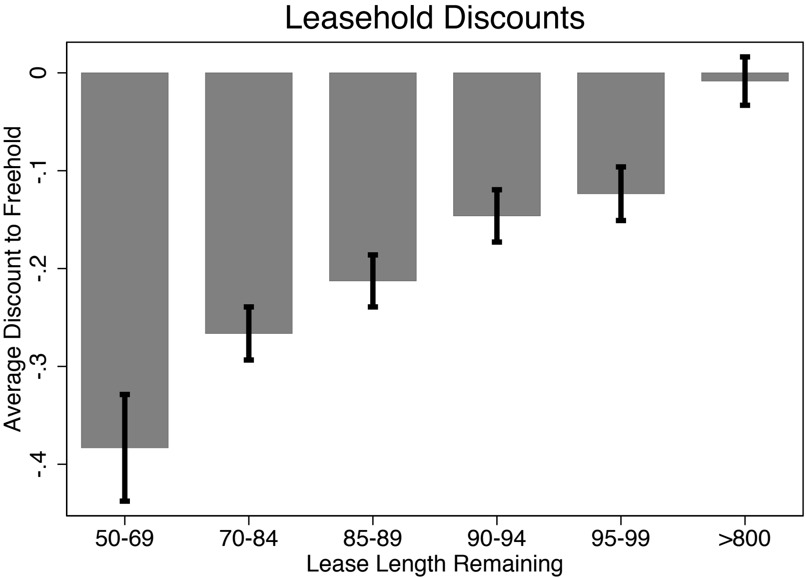
$$\log\left(Price\right)_{i,g,t} = \alpha + \sum_{j \in TenGroup_j} \beta_j \mathbf{1}_{\{RemainLeaseLength_i \in j\}} + \gamma Controls_{i,t} + \\ + \phi_g \times \psi_t + \epsilon_{i,g,t}$$

- $TenGroup_j$: Buckets of *remaining* lease length
- ϕ_g: 3-digit Postcode Fixed Effect
- ψ_t: Time Fixed Effect (Month)
- **Controls**: Age, Number of bedrooms and bathrooms, Property size, Property style, Garage, Heating type
- Standard errors are clustered at the year and postcode level

Hedonic Regressions: UK Results - Flats



Leasehold Discounts - Singapore



Key Take-Aways

- Sizable discounts for relatively long-run leaseholds.
- Very similar leasehold discounts observed for U.K. houses and in Singapore.
- Slope of the term structure of leasehold discounts suggests discounts related to remaining lease length.
    - **Our interpretation:** Related to different duration of cash flows (rents), and therefore informative about very long-run discount rates
    - Address other possible interpretations.

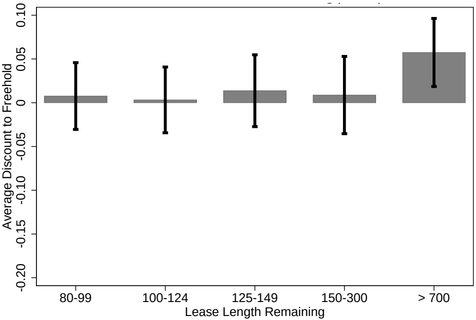
Other explanations

- **Unobservable Differences in Property Characteristics**:
  - 700+ year leaseholds priced identically to freeholds.

Other explanations

- **Unobservable Differences in Property Characteristics**:
  - 700+ year leaseholds priced identically to freeholds.
  - Test whether they rent for the same annual amount

$$\log\left(Rent\right)_{i,g,t} = \alpha + \sum_{j \in TenGroup_j} \beta_j \mathbf{1}_{\{RemainLeaseLength_i \in j\}} + \gamma Controls_{i,t} + \epsilon_{i,g,t}$$



No unobserved differences in hedonics that vary with lease length

Other explanations

- **Contractual Restrictions on Leaseholders**:
  - Would also show up for 700+ year leaseholds
  - Same result when estimating discounts relative to 300 year leasehold
  - Results hold after controlling for initial lease length
- **Differences in Buyer Characteristics**:
  - Leaseholders and freeholders look the same on observables
- **Liquidity or Financing Frictions**:
  - Similar "time on market" to sell freeholds and leaseholds
  - Leaseholds with > 70 years mortgage financed identically to freeholds
  - Marketing identical

Risk and Return of Housing

- Find **high expected real returns** (7%+), low rent growth (0.5%)
- Most of the return comes from dividend yield, not capital gain
- High returns consistent with **riskiness** of housing
  - House prices decline during consumption disaster, banking crises, wars
  - House prices growth and consumption growth are correlated

Interpreting the results

- **Main Empirical Findings:**
  - Significant discount for leaseholds vs. freeholds
  - High average expected returns (above 6.5%), low rent growth (0.7%)

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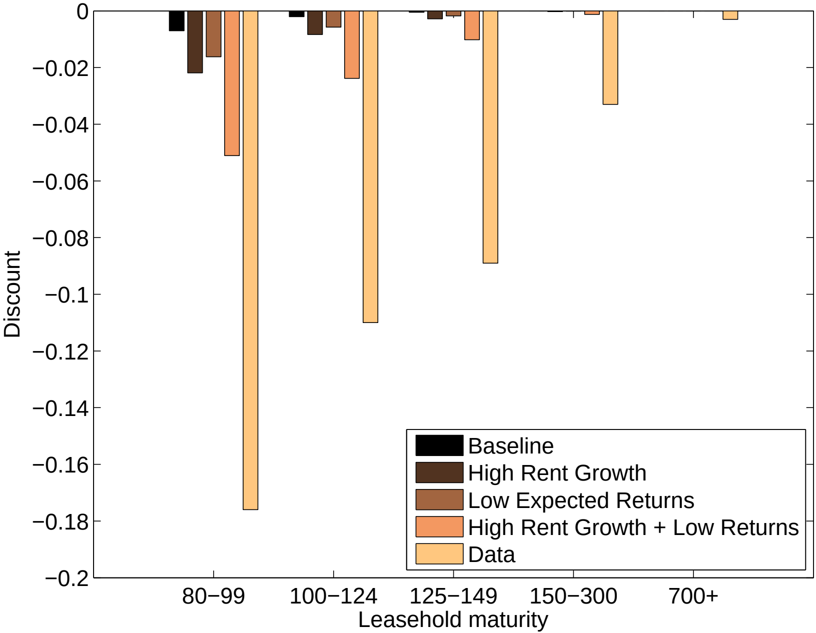
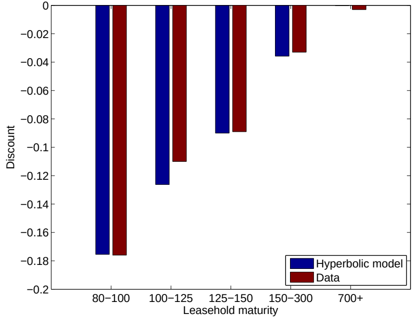
- Models with upward-sloping term structures of risk premia explain the average returns but not the leasehold discounts

Robustness: UK



Interpreting the Results

- **Bottom line: need low long-run discount rates (around 2-3%)**
- Plus high short-term discount rates to explain high expected returns:
    - Hyperbolic-Exponential reduced-form model: $\frac{e^{-\rho T}}{1+kT}$



(a) Leasehold-Freehold discounts

Interpreting the Results

- **Low long-run total discount rate:**
  - Low long-run risk-free rate
    - Informative for pricing safe investments over long horizon
  - Low long-run risk premium
    - Either long-run rents are very safe (low quantity of long-run risk), or long-run price of risk is low.
- **Riskiness of long-run rents?**
  - Insufficient data to answer conclusively
  - Some evidence that long-run rents are not safe:
    - Long-run cointegration with consumption
    - Major declines during rare disasters

  $\rightarrow$ Our results also useful to price risky investments over long horizon

Discounting: a review

- The "right" value of an asset weighs payments by "marginal utility" (the SDF ξ):

$$P_{t+n}(t) = E\left[\xi_{t+n} D_{t+n}\right]$$

- Alternatively, given P we can find the corresponding discount rate s.t.:

$$P_{t+n}(t) = \frac{E\left[D_{t+n}\right]}{(1+R_n)^n}$$

- Each horizon has its own ξ_{t+n}, so it will have its own R_n

Discounting: a review

- Now consider a claim to many dividends (e.g. the stock market):

$$P(t) = E\left[\xi_{t+1} D_{t+1} + \xi_{t+2} D_{t+2} + ... + \xi_{t+n} D_{t+n}\right]$$

  or (it's a bundle of period-specific claims):

$$P(t) = \frac{E\left[D_{t+1}\right]}{1+R_1} + \frac{E\left[D_{t+2}\right]}{(1+R_2)^2} + ... + \frac{E\left[D_{t+n}\right]}{(1+R_n)^n}$$

- If we know P we can **also** find that particular R s.t.

$$P(t) = \frac{E\left[D_{t+1}\right]}{1+R} + \frac{E\left[D_{t+2}\right]}{(1+R)^2} + ... + \frac{E\left[D_{t+n}\right]}{(1+R)^n}$$

  where R is the same for **all** cash flows. This is the **average** return.

Discounting: a review

- Important observation: from P I can find R. From R I cannot find all the R_n of every period
- For example, I cannot know the correct value of a claim to $D_{t+2}, ..., D_{t+n}$
- **The average discount rate for a bundle of different maturities cannot be used to discount a different combination of maturities**

Discounting: a review

- Our results speak directly to this problem.
- We find the term structure of discount rates (of R_n) to be downward sloping.
- The average is high even though the long end is low
- A project whose cash flows arise in the future should be discounted using the appropriate R_n
- But the average rate of return R is uninformative about R_n

Risk

- A second crucial point is that for any two securities, fixing the maturity, we have:

$$R_A > R_B \iff Corr(\xi_{t+n}, D^A_{t+n}) > Corr(\xi_{t+n}, D^B_{t+n})$$

- The risk premium can be decomposed as:

$$R_A - R_f = \beta_{A,\xi}\lambda_{xi}$$

  where β is the risk exposure and λ is the price per unit of risk

- How exposed to systematic risks are the housing claim and climate change risk?

- A third point is that if climate change is **risky**, then climate change **reduction** is a **hedge**, so the discount rate applied should be **lower than** R^f.

Discounting Climate Change

- What discount rate for long-run environmental policies?
  - Answer depends crucially on: 1) Climate change β 2) Long-run Rf 3) Long-run Risk price
  - Our study provides evidence for Rf and Risk price
  - Low Rf: people care about the future
  - If climate-change policies are hedges ($\beta < 0$), risk-adjustment (which depends on beta) can push discount rate close to 0
  - However, low long-run risk premium makes the optimal decision less sensitive to the exact choice of β
- Three main **implications for climate change policy**:
  - Long-run discount rates are the right rates to look at
  - High willingness to pay to reduce very long-run climate costs **for sure**
  - Low discount rates for wide range of climate change β

Conclusion

- Exploit unique feature of housing markets in the UK and Singapore
- Provide first direct estimate of very long-run discount rates (100+ y)
  - Long-run discount rates are low ($< 2.5\%$), much lower than suggested by most asset pricing models.
  - To also match expected returns, need a term structure of discount rates that slopes down in the long-run.
  - Low long-run risk-free rate, and low price of long-run risk.
- Important imput for many policy questions:
  - Evaluating climate change policy (and other cost-benefit analyses)
  - Long-run implications of fiscal policy
  - Large infrastructure spending, education policy, ...

BACKUP SLIDES

Freehold Properties' Expected Returns

- Balance Sheet approach: National Accounts Data
- Price/Rent approach: Price series + Initial Baseline

	United States		Singapore		United Kingdom	
	Balance Sheet	Price/Rent	Balance Sheet	Price/Rent	Balance Sheet	Price/Rent
Gross Return	10.3%	10.7%	10.4%	10.3%	12.5%	10.9%
Rental Yield	8.3%	9.8%	6.1%	6.0%	9.7%	6.9%
Capital Gain	2.0%	0.8%	4.3%	4.3%	2.8%	4%
Depreciation	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
Taxes	0.67%	0.67%	0.5%	0.5%	0%	0%
Real Net Return	**8.1%**	**8.5%**	**8.4%**	**8.3%**	**11%**	**9.4%**
Sample	1953-2012	1988-2012	1985-2012	1990-2012	1989-2012	1996-2012
Real Rent Gr.		**0.1%**		**0.2%**		**0.7%**
Sample		1988-2012		1990-2012		1996-2012

Other explanations

- **Hold-up problem for leaseholders at extension**:
  - 1993 law: right to extend at "reasonable" price $\Rightarrow$ Mitigates hold-up
  - Leaseholder can resort to court: tribunal favorable to leaseholders
  - Court protection makes leaseholds more valuable $\Rightarrow$ Bias against our findings
  - Additional value offset by: transaction costs, long bargaining times, legal fees, legal uncertainty

Buyer Characteristics

- Segmented Markets? Buyers for different contract types could be different.
- Survey of English Housing (SEH) - Annually between 1994 and 2008.
- 200,000 observations

$$Outcome_i = \alpha + \beta Leasehold_i + \xi X_i + \phi_{PropertyType \times Region} + \varepsilon_i.$$

Buyer Characteristics

Table: Characteristics of Buyers of Leaseholds and Freeholds

	Sample			Leasehold Δ	
	Mean	St. Dev.	Unconditional	Conditional I	Conditional II
	(1)	(2)	(3)	(4)	(5)
Age Head of Household (years)	52.30	16.01	-2.68	-1.54	-1.30
				(0.21)	(0.20)
Weekly Income (£)	350.2	450.6	-48.07	-3.01	5.60
				(4.56)	(4.45)
Number of people in household	2.53	1.27	-0.48	-0.03	0.02
				(0.01)	(0.01)
Number of dependent children	0.55	0.94	-0.19	-0.01	0.02
				(0.01)	(0.01)
Head of Household Married	0.64	0.48	-0.21	-0.01	0.01
				(0.01)	(0.01)
First Time Buyer	0.40	0.48	0.11	-0.00	-0.01
				(0.01)	(0.01)
Currently Has Mortgage	0.59	0.49	0.03	0.02	0.02
				(0.01)	(0.01)
Very Satisfied with Neighborhood	0.47	0.50	-0.06	0.00	0.00
				(0.00)	0.00

Return

Financing Frictions

- Harder to mortgage-finance leases with short remaining duration.
- UK: No issues for leaseholds with more than 60-70 years remaining; these are treated like freeholds

Mortgage Lender	Leasehold Financing Rules
The Royal Bank of Scotland	Mortgage term plus 30+ years
Santander	Unexpired lease term 55+ years, 30+ years at mortgage end
HSBC	Mortgage term plus 25+ years
Nationwide Building Society	Unexpired lease term 55+ years, 30+ years at mortgage end
Lloyds TSB	Unexpired lease term 70+ years, 30+ years at mortgage end
Halifax	Unexpired lease term 70+ years

Financing Frictions

Some elements mitigate financing frictions:

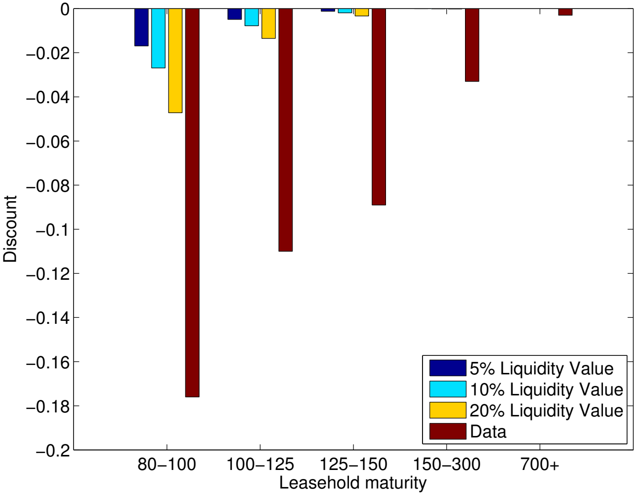
- Right to lease extensions in UK
- If the problem is liquidity, then leaseholds are more attractive

We parametrize reduced-form model of “collateral value of housing":

$$
\begin{aligned}
P_t^T &= \int_t^{t+T} e^{-\rho(s-t)} D_t e^{g(s-t)} (1 - \alpha \mathbf{1}_{\{s>t+T-\bar{T}\}}) ds = \\
&= \frac{D_t}{\rho - g} \left[1 - e^{-(\rho-g)T} - \alpha \left(e^{-(\rho-g)(T-\bar{T})} - e^{-(\rho-g)T} \right) \right].
\end{aligned}
$$

A fraction α of the rents are lost when the remaining lease length is less than $\bar{T}$

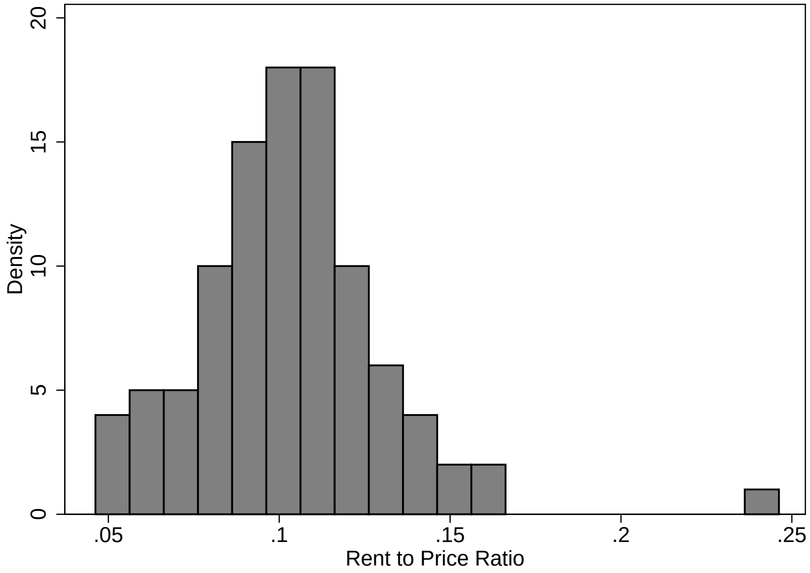
Data Vs Model with Frictions



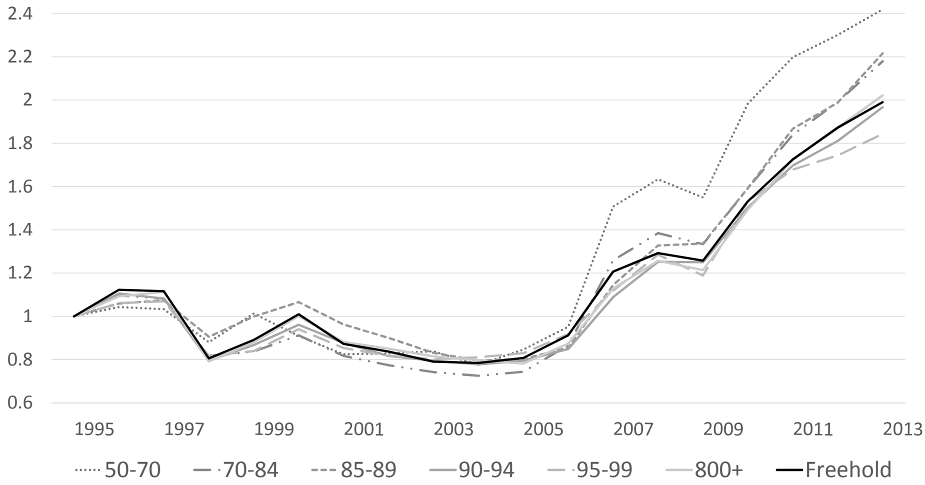
- Take Away: frictions have essentially no impact on long-maturity leases: e.g. 150-years

Return

Rent-Price Ratio: 100 Largest MSAs



Singapore Time Series



Housing is Risky

	Real HP Growth		Real PDI Growth		
	Mean	Std. Dev.	Mean	Std. Dev.	Correlation
Australia	3.20%	6.89%	1.43%	2.77%	0.093
Belgium	2.80%	5.87%	1.17%	2.27%	0.436
Canada	2.51%	7.63%	1.37%	2.10%	0.489
Switzerland	0.94%	4.73%	1.12%	1.63%	0.445
Germany	-0.29%	2.31%	1.27%	1.70%	0.288
Denmark	1.57%	8.99%	1.09%	2.29%	0.211
Spain	2.05%	8.26%	0.83%	2.46%	0.631
Finland	2.04%	8.19%	2.07%	3.21%	0.482
France	2.52%	5.23%	1.22%	1.58%	0.358
U.K.	3.53%	8.54%	2.20%	2.74%	0.355
Ireland	3.70%	9.73%	1.83%	3.59%	0.529
Italy	0.60%	8.28%	0.82%	2.44%	0.325
Japan	-0.24%	4.28%	1.55%	1.40%	0.587
S. Korea	0.59%	7.70%	3.95%	4.58%	0.235
Luxembourg	3.94%	6.68%	2.84%	3.75%	0.054
Netherlands	2.32%	9.43%	0.48%	3.25%	0.472
Norway	2.76%	7.23%	2.22%	2.52%	0.064
New Zealand	2.20%	7.73%	0.98%	3.45%	0.530
Sweden	1.50%	7.27%	1.34%	2.28%	0.431
U.S.	1.13%	3.89%	1.60%	1.56%	0.371
S. Africa	0.88%	9.65%	0.53%	3.05%	0.373

Return

Robustness: cointegration argument

- In the model, the effective discounting for the long run depends on $r - g$.
- What if g becomes really big? (superstar-city effect)
- If prices and rents are cointegrated, in the long run g and capital gains have to grow at the same rate
- If g explodes, CG explodes, and $r - g = CG + DY - g = DY$.
- But real, net DY is always at least 4% -> net price-rent ratio of 25 at the most.
- Still, way too large.

Return

Infinitely-Lived Rational Bubbles

Classic infinitely-lived rational bubble models: Blanchard and Watson (1982) and Froot and Obstfeld (1991)

- Rely on failure of the no-bubble condition:

$$\lim_{T\to\infty} E_t[\xi_{t,T} P_T] \neq 0,$$

  For some model-implied SDF $\xi_{t,T}$

- Long literature attempted indirect tests: afflicted by serious econometric problems
- We provide a simple direct test:

$$H_0: \quad P_t - P_t^T \approx \lim_{T\to\infty} E_t[\xi_{t,T} P_T] = 0, \qquad \text{for large T.}$$

- We find no evidence of infinitely-lived rational bubbles even at the peak of the housing-boom (2006-7) in London and Singapore

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Real Net Return	**8.1%**	**8.5%**	**8.4%**	**8.3%**	**11%**	**9.4%**
Sample	1953-2012	1988-2012	1985-2012	1990-2012	1989-2012	1996-2012
Real Rent Gr.		**0.1%**		**0.2%**		**0.7%**
Sample		1988-2012		1990-2012		1996-2012

Return

Rational bubbles: Singapore