Long-Run Discounting
PhD Lecture

Stefano Giglio
Chicago Booth

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Term structures

- Many economic questions have an important **horizon** dimension
- In finance:
  - Dynamics of the economy and transmission of shocks
  - Preferences for risk and return across horizons
  - Long-term investment risks
- In macro:
  - Fluctuations of the economy
  - Transitory vs. permanent shocks
  - Long-term growth and permanent shocks

Term structures

- We can learn a lot from **term structure of asset prices**
  - Traditionally: term structure of interest rates,
  - Dividend term structure (Binsbergen et al. 2012),
  - Volatility term structure (Dew-Becker et al. 2017)...
- **Term structures reflect investors' beliefs and risk perceptions across horizons**
- They represent a powerful set of moments to estimate and test models

The Very Long Run

- A special role is played by the **very long run** (i.e., hundreds of years)
- Crucial in many fascinating economic questions
  - **Climate change**: trade-off immediate costs and very distant benefits
  - **Fiscal policy**: intergenerational questions
- So far, little direct empirical evidence on very long-run discount rates

The Very Long Run

- 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

What I'll talk about today

1. What we can learn from housing data about very long run discounting
2. What that tells us about standard asset pricing models
3. What that tells us about climate change
4. Avenues for future research

Discounting across horizons: a review

Discounting: a review

- The “right” value of an asset weighs payments by “marginal utility” ξ:

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

- ξ_{t+n} captures my marginal utility in possible states of the world during period $t+n$
- Suppose the only risk in the economy is climate change risk
- Suppose we are sure nothing bad can happen for the next 20 years, all the risks come after that
- For $n < 20$, ξ is constant: there will be no "bad" states of the world
- ξ_{t+n} will vary across states (and affect the expectation) only for $n > 20$
- The risk perception is very different across horizons!

From ξ to discount rates

- The **fundamental** representation starts from marginal utility ξ:
  $P_{t+n}(t) = E\left[\xi_{t+n} D_{t+n}\right]$

- Given P, we can find a “discount rate" such that: s.t.:

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

- Note: we are talking about claims to a **single** cash flow at $t+n$, D_{t+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**
- If my tradeoff involves cash flows at $n = 100$, I need to know R_n for that n
- In our empirical work, we provide estimates of the whole term structure of R_n for maturities of hundreds of years
- We find the term structure of discount rates (of R_n) to be **downward sloping**, and discount rates to be low at long horizons

What can we learn from housing data about very long run discounting?
(*Giglio, Maggiori and Stroebel, QJE 2016*)

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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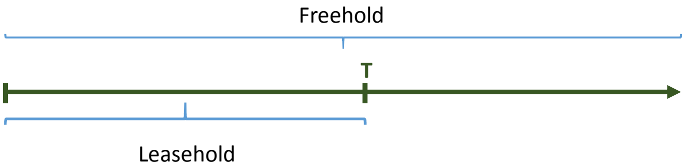

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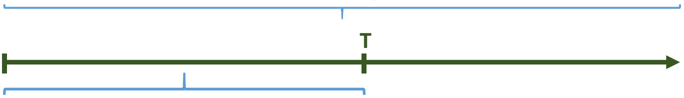
Freehold: $P = \frac{D}{r-g}$



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

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$$Discount^T \equiv \frac{P^T}{P} - 1 = -e^{-(r-g)T}$$

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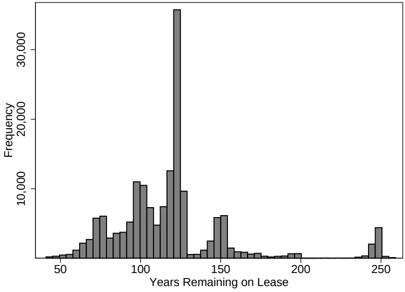
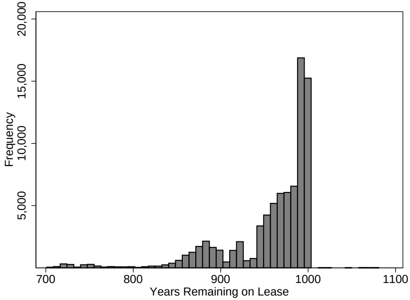
$$Disc^{100} \equiv \frac{P^{100}}{P} - 1 = -e^{-(0.065-0.007)100} = -0.3\%$$

Data for the UK

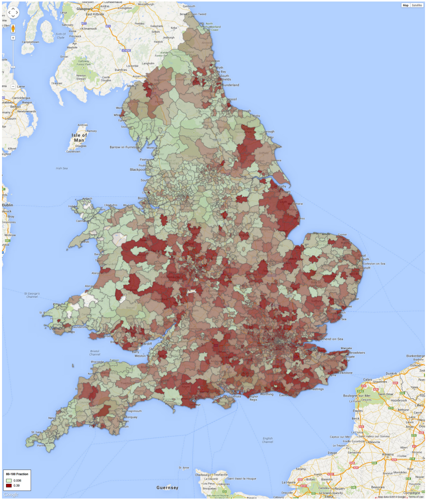
- Administrative data on all transactions and lease terms since 2004
  - 1.3 million transactions for flats
  - 8% Freeholds; Initial lease length distributed between 99 - 999 years
- Property characteristics, listings and rental data from Rightmove.co.uk



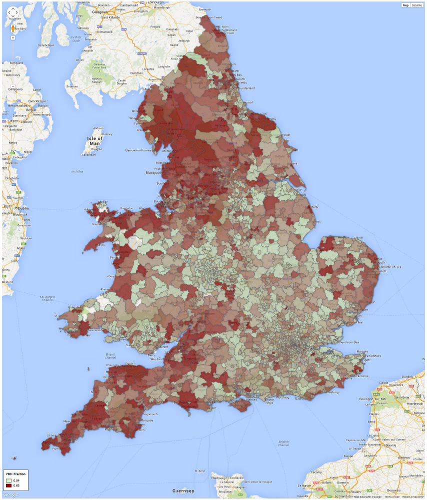


Data for the UK

Geographic Distribution of Flats



(c) 80-100 years leaseholds



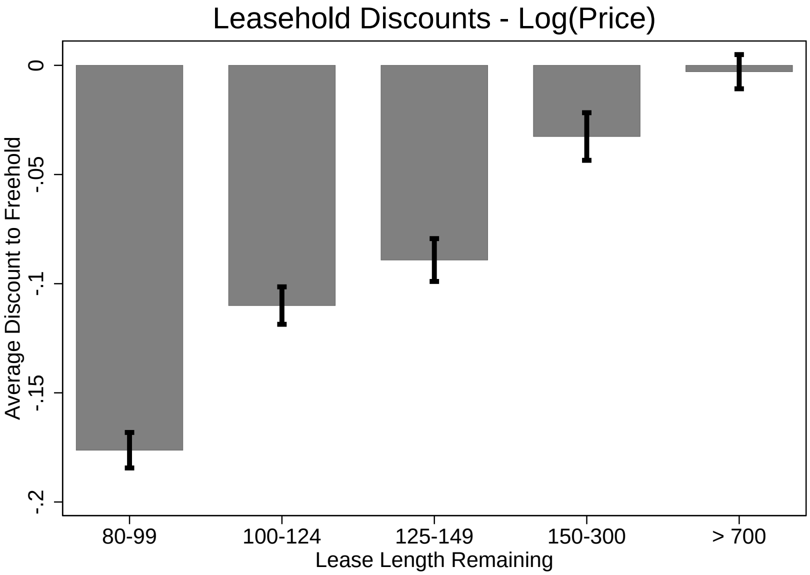
(d) 700+ years leaseholds

Hedonic Regressions: Specification

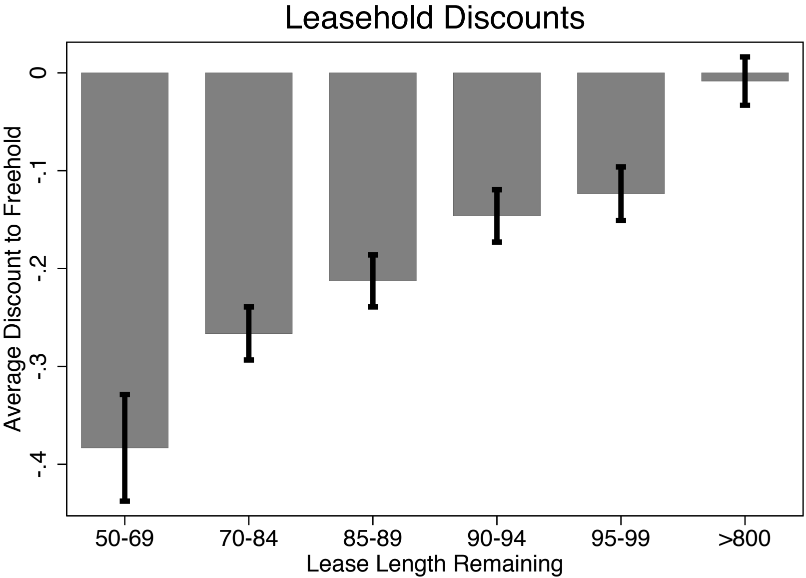
$$\log(Price)_{i,g,t} = \alpha + \sum_{j \in TenGroup_j} \beta_j \mathbf{1}_{\{RemainLeaseLength_i \in j\}} + \gamma Controls_{i,t} + \\ + \phi_g \times \psi_t + \epsilon_{i,g,t}$$

- $TenGroup_j$: 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 in the papers.

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%)
- Constant-discount-rate model with $r = 6.5\%$, $g = 0.7\%$ won't work:

$$Disc_t^{100} = -e^{-(\mathbf{0.065}-0.007)100} = -0.3\%$$

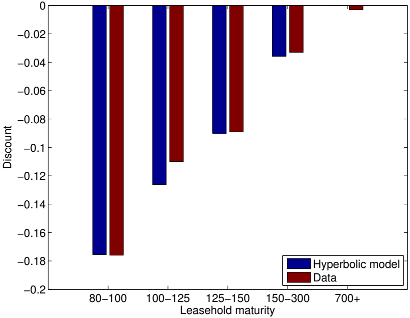
- Constant-discount-rate model with $r = 2.6\%$, $g = 0.7\%$ explains discounts but not average return:

$$Disc_t^{100} = -e^{-(\mathbf{0.026}-0.007)100} = -15\%$$

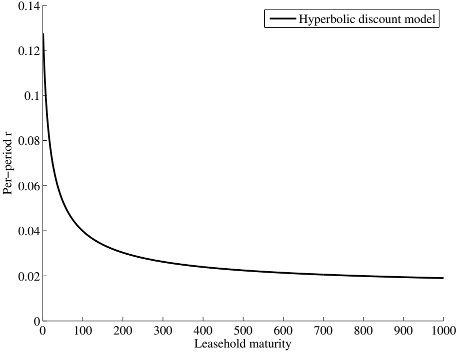
- Models with upward-sloping term structures of risk premia explain the average returns but not the leasehold discounts

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: $\frac{e^{-\rho T}}{1+kT}$



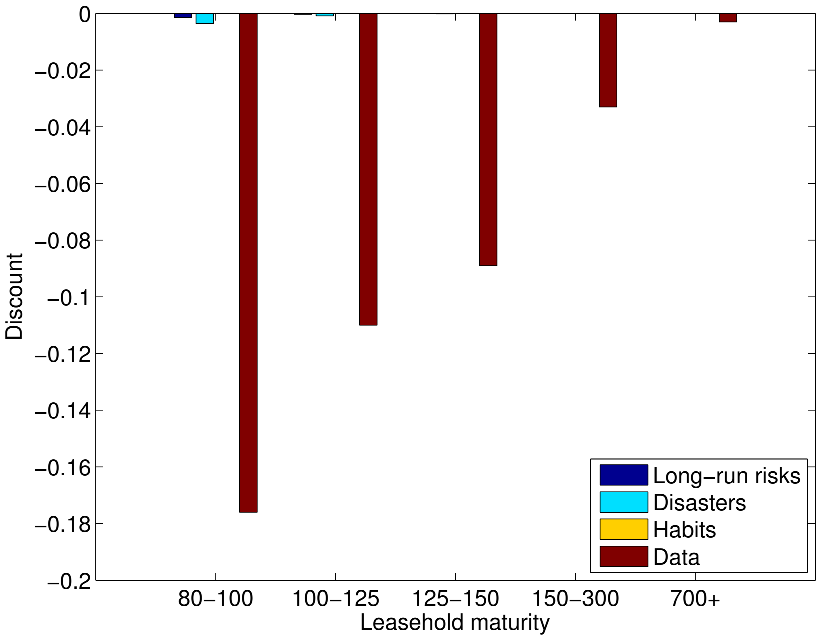
(e) Leasehold-Freehold discounts



(f) Per-period discount rates

What do asset pricing models have to say?

Data vs. Model: UK



Interpreting the Results

- Our standard models imply a **flat or upward-sloping term structure of discount rates**
  - E.g.: long-run risks models: long-term claims are especially risky because they are more exposed to news about future consumption growth
- What can explain the downward slope for a risky asset?
  - Is it decreasing quantity of risk?
  - Is it decreasing price of risk?
- **Open question: what structural model can explain the low long-run discount rates, and downward slope, in this and other term structures?**
  - Key moments to match
  - Average return: **6.5%**
  - Long-run (100yr+) discount rate: **2.5%**

Interpreting the Results

- One reduced-form model that works is Lettau and Wachter (2007)
  - Mean reversion in cash flows
  - Exogenously specified SDF
- Recent related work:
  - Binsbergen and Koijen (2017): review across asset classes
  - Dew-Becker and Giglio (2016): frequency domain decomposition
  - Berrada, Detemple, and Rindisbacher (2017): regime-dependent preferences
  - Nakamura, Steinsson, Barro, and Ursua (2013): disasters with recovery
  - Belo, Collin-Dufresne, and Goldstein (2014), Marfe (2014): change the earnings and dividend process
  - Croce, Lettau, and Ludvigson (2014): bounded rationality

Applications I: bubbles
Giglio, Maggiori and Stroebel, Ecma 2016

Rational bubbes?

- Asset pricing equation:

$$P_t = E_t[\xi_{t,t+1}(P_{t+1} + D_{t+1})]$$

For $\xi_{t,t+1}$ a valid SDF, P the price of the asset, D the dividend

- Iterating forward:

$$P_t = \underbrace{\sum_{s=1}^{\infty} E_t[\xi_{t,t+s} D_{t+s}]}_{Fundamental\ \ Value} + \underbrace{B_t}_{Bubble}, \qquad B_t \equiv \lim_{T\to\infty} E_t[\xi_{t,t+T} P_{t+T}]$$

$$B_t = E_t[\xi_{t,t+1} B_{t+1}] \qquad B_0 > 0$$

Rational bubbes?

- We can obtain a *model-free* test of infinitely lived rational bubbles
- No-bubble condition: $\lim_{T\to\infty} E_t[\xi_{t,T} P_T] = 0$
- Long literature attempted indirect tests: serious econometric problems
  - In particular: explosive prices or just temporarily high discount rates?
- We provide a simple direct test:

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

- No evidence of this type of bubble in Singapore or the UK in the last 20 years, using $T > 700 yrs$.

Applications II: Climate Change
(*Giglio, Maggiori, Stroebel, and Weber, 2017*)

Interpreting the Results

- Our results show that for an important risky asset class (housing), the term structure of discount rates is **downward sloping**
- This suggests that we should be wary of using **average** returns to assets (capital, housing) to evaluate climate change policies
- What else can we learn from these results?
- To talk seriously about climate change, need to think seriously about **risk** in addition to **maturity**

Risk

- Remember the pricing equation:

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

- The relevant notion of risk is the **covariance**, or **beta**, with marginal utility
  - A cash flow with zero beta with ξ_{t+n} should be discounted at the risk-free rate
  - A cash flow with positive beta with ξ_{t+n} should be discounted **less** than the risk-free rate
  - A cash flow with negative beta with ξ_{t+n} should be discounted **more** than the risk-free rate
- When we think about climate change abatement policies, we need to understand the covariance of the payoff to the policy with ξ_{t+n} at each horizon

Discounting Climate Change

- Long-run discount rates (risk-free rate + risk premium) are low
  - So **both** risk-free rate and risk premium are low
  - Low risk-free rate: people care about the very long-run
  - If climate-change policies are hedges ($\beta < 0$), the appropriate discount rate must be even lower
  - Risk adjustment can push discount rate close to 0
- Housing is likely exposed to the overall state of the economy
  - It may be a reasonable proxy for a claim to long-run consumption
  - Much more work needed to establish the risk properties of housing
- For climate change policy, we want to focus on the riskiness of the appropriate horizon (very long-run)
- Lettau and Wachter (2007) is a good starting model

Open questions and potential research avenues

Open questions and potential research avenues

- What explains the downward sloping term structure in housing?
  - Structural models are necessary
  - Microfoundations for the result
  - Important to decompose risk and risk premia across horizons
- Many term structures
  - Long-run prices and term structures from other asset classes
  - What are the links between the various term structures?
- What do these results tell us about macro?
  - E.g., intergenerational fiscal policy?
  - Positive and normative analysis