Section 12: Real Estate

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1. Basic structure of the notes

- High-level summary of theoretical frameworks to interpret empirical facts.
- Per asset class, we will discuss:
  1. Key empirical facts in terms of prices (unconditional and conditional risk premia) and asset ownership.
  2. Interpret the facts using the theoretical frameworks.
  3. Facts and theories linking financial markets and the real economy.
  4. Active areas of research and some potentially interesting directions for future research.
- The notes cover the following asset classes:
  1. Equities (weeks 1-5).
     - Predictability and the term structure of risk (week 1)
     - The Cross-section and the Factor Zoo (week 2)
     - Intermediary-based Asset Pricing (week 3)
     - Production-based asset pricing (week 4)
     - Demand-based asset pricing (week 5)
  2. Mutual Funds and Hedge Funds
  3. Options and volatility (week 7).
  4. Government bonds (week 8).
  5. Corporate bonds (week 9).
  6. Currencies (week 10).
  7. Commodities (week 11).
  8. Real estate (week 12).

2. Real Estate

- Real estate is a large area of research in both finance and economics, reflecting its important role in household and institutional portfolios, and its importance for the macro-economy.
- Real estate was at the heart of the Great Financial Crisis of 2007-2009, and this has resulted in a surge in academic work (published in the top outlets) in the past decade.
- Real estate can be split into residential real estate (= housing), and commercial real estate (income-producing property).
- Real estate assets are funded with equity and debt.
  - There is public equity (REITS) and private equity (REPE)
  - There is public debt (RMBS, CMBS) and private debt (e.g. mezzanine debt, loans on bank balance sheets).
- First-lien debt is known as a mortgage (residential or commercial). Mortgage debt is collateralized by the property. Upon default, mortgage lenders have the right to foreclose on the property (power of sale clause, at least in non-judicial states).
- There can be a second-lien mortgage or unsecured debt (mezzanine debt), which is junior to the first-lien mortgage.
- Property usually refers to the combination of land and structure (fee simple, freehold). Sometimes, ownership of land and structure are separated. Owner of the structure may not own the land (leasehold). Property is subject to a ground lease, whereby property owner pays rent for the land. Ground lease is super-senior.

- The focus today is on real estate as an investment. There is only so much we can cover in one lecture, but hopefully it provides an introduction into the area.
- We will cover housing, residential mortgages, and commercial real estate. First some facts, then some theories to shed light on the facts.

2.1. Stylized Facts in Housing Markets

2.1.1. Residential Real Estate as an Asset Class

- Residential real estate constitutes the largest asset on household balance sheets: $36.8 trillion in 2021.Q3,
  Stocks and mutual funds: $42.6 trillion,
  Deposits and money market funds: $13.5 trillion.

- Residential RE wealth has grown by $17 trillion since crisis. Driven by new house price boom.

- Residential mortgage debt largest household liability: $12 trillion. Now back to same level as 2007.

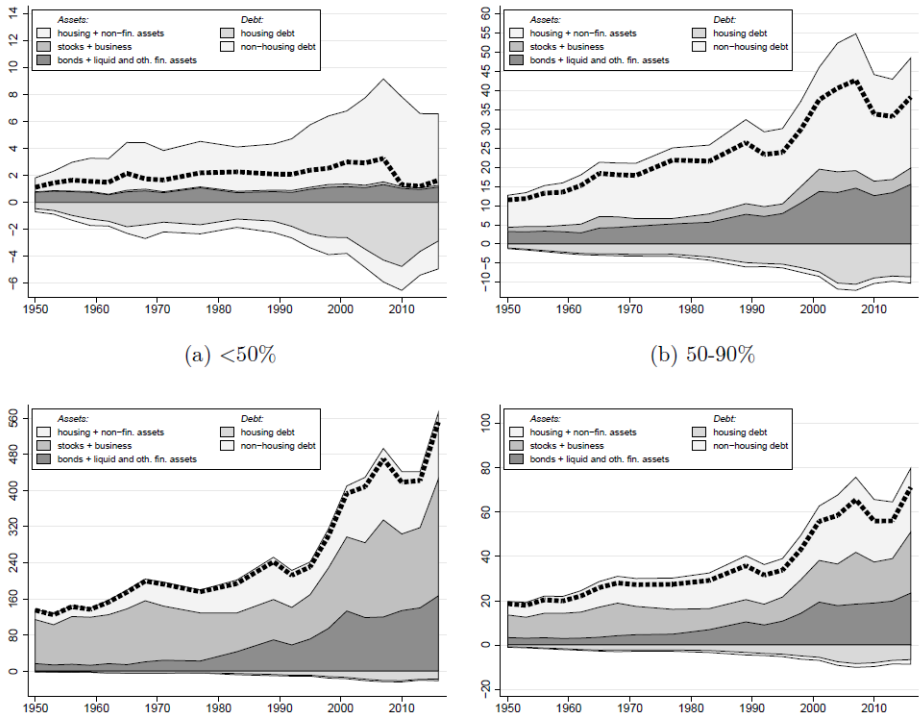
- Home equity at new all-time high of $25.3 trillion in 2021.Q2 (68.7% of home value = 31.3% LTV in the aggregate).

- Housing and mortgages are disproportionately important for the middle class (50-90th percentile of wealth distribution).

  - The poor usually rent
  - The rich own most of the stock market wealth (and a lot of private business wealth). For the rich, housing makes up only a modest portion of their portfolio.
  - For the middle class, financial assets usually make up less than 5% of assets.

- From Kuhn, Shularick, and Steins (2020):

Figure 13: Heterogeneity of household portfolios



(a) <50% (b) 50-90%

(c) 90-100% (d) all households

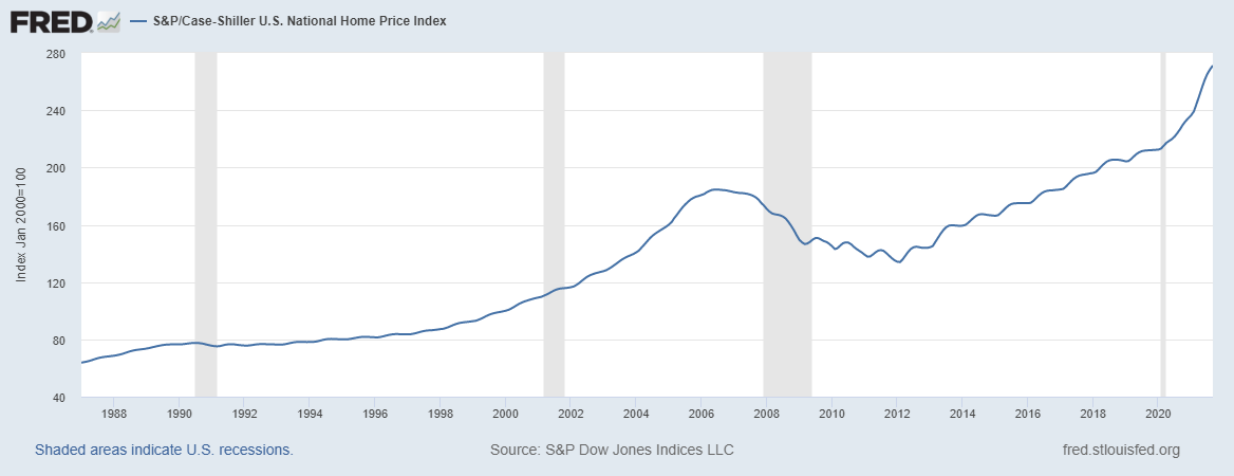
Notes: Household portfolios for four wealth groups. Light gray areas show nonfinancial assets, dark gray areas financial assets, and negative areas housing and nonhousing debt. The dashed line indicates wealth. Panel (a) shows portfolio of the bottom 50% of the wealth distribution, panel (b) portfolio of the 50%-90%, and panel (c) portfolio of the top 10%. Panel (d) shows the portfolio of all households. Portfolio components are shown in 10,000 CPI-adjusted 2016 dollars. Wealth groups are separately defined for each survey year.

- The Survey of Consumer Finances has this data for U.S., the European Household Finance and Consumption Survey for Europe.

2.1.2. House Prices

- Data sources:
  - Zillow research: Zillow Home Value Index and Zillow Rental Index, at national, state, county, and ZIP code level
  - Core Logic S&P Case-Shiller house price index, national and for 20 largest metropolitan statistical areas (MSAs); also data available at the ZIP-code level
  - FHFA house price index
  - Black Knight house price index
  - At the household level, there are self-reported home values in the Panel Study of Income Dynamics; PSID also has wealth supplement files including mortgage information.
- Two house price index methodologies:
  - Hedonic indices: control for property characteristics in cross-sectional regression; see Silver (2016) for a review
  - Repeat-sales indices: control for property characteristics by focussing on two sales of the same property; often results in much smaller sample
  - In general, it is hard to control for quality changes due to renovations.
    - New data on home remodeling permits from Buildzoom in California; see Giacoletti and Westrupp (2018)

- Housing markets went through a major bust after having gone up for 135 months in a row (1994-2006), nationwide. Based on Case-Shiller national house price index:
  - **Boom: +10.5%** per year (compounded) from April 2001 – April 2006; peak is in 2006.Q2
  - **Bust: -7.1%** per year from May 2006 – May 2009; Cumulative bust: -26% nationwide. Followed by 3 years of stagnation.
  - **Recovery: +6.3%** per year from Feb 2012-Sept 2020, to new all-time high
  - Latest numbers (as of Sept 2021): **unprecedented**
    - Zillow House value index (*hedonic index*): +18.9% yoy
    - Black Knight's *repeat sales index*: +18.5% yoy
    - S&P Case-Shiller HPI (*repeat sales*): +19.5% yoy



- This graph shows that house prices are **volatile** in the time-series, much more so than initially thought and common perception.
  - HPA: 12-month log change in HPI, sampled every 12 months, 1988.01-2021.09
  - Mean HPA: 4.2% (nominal)
  - Standard deviation of annual HPA: 5.6%.
  - HPA is persistent with annual AC coefficient of 0.70
- Enormous **variation** in amplitude (and even timing) of the boom-bust-boom **across metropolitan areas**
  - Pattern: biggest boom, biggest bust, biggest recovery
  - Ex. Phoenix, Los Angeles, Las Vegas ("sand states")
  - 12 of top-15 MSAs exceed their pre-crisis peak HPI

MSA	HPI changes (%)			% above peak
	2000 to peak	Peak to trough	Trough to current	
United States	74.9	-25.2	59.9	19.6
New York-Jersey City-White Plains, NY-NJ	127.7	-22.5	50.4	16.6
Los Angeles-Long Beach-Glendale, CA	179.4	-38.1	95.7	21.1
Chicago-Naperville-Arlington Heights, IL	67.2	-38.4	48.5	-8.6
Atlanta-Sandy Springs-Roswell, GA	32.3	-35.0	85.9	20.8
Washington-Arlington-Alexandria, DC-VA-MD-WV	149.0	-28.3	43.0	2.4
Houston-The Woodlands-Sugar Land, TX	29.2	-6.6	52.2	42.1
Phoenix-Mesa-Scottsdale, AZ	113.1	-51.0	108.5	2.1
Riverside-San Bernardino-Ontario, CA	174.5	-51.6	97.0	-4.7
Dallas-Plano-Irving, TX	26.3	-7.3	71.9	59.4
Minneapolis-St. Paul-Bloomington, MN-WI	69.2	-30.6	67.1	16.0
Seattle-Bellevue-Everett, WA	90.3	-33.1	114.0	43.1
Denver-Aurora-Lakewood, CO	34.1	-12.2	97.7	73.5
Baltimore-Columbia-Towson, MD	123.2	-24.4	24.9	-5.5
San Diego-Carlsbad, CA	148.1	-37.4	85.6	16.1
Anaheim-Santa Ana-Irvine, CA	163.2	-35.2	70.9	10.7

Sources: Black Knight HPI and Urban Institute. Data as of September 2020.
Note: This table includes the largest 15 Metropolitan areas by mortgage count.

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- Start date of the boom was very heterogeneous. Ranged from 1995 to 2006; see structural break analysis in Ferreira and Gyourko (2012).

- This shows that house prices are volatile in the cross-section, even more so than in the time series. The finer geography, the larger the cross-sectional dispersion (state, county, ZIP code, HH).

- Dispersion/inequality in regional house prices has been rising since at least the 1970s (Van Nieuwerburgh and Weil 2010)

- At the individual property level, within a metropolitan area, the stylized fact is that both the boom and the bust were larger for lower-quality/cheaper houses typically occupied by lower-income households.

- Landvoigt, Piazzesi, and Schneider (2012) study San Diego:

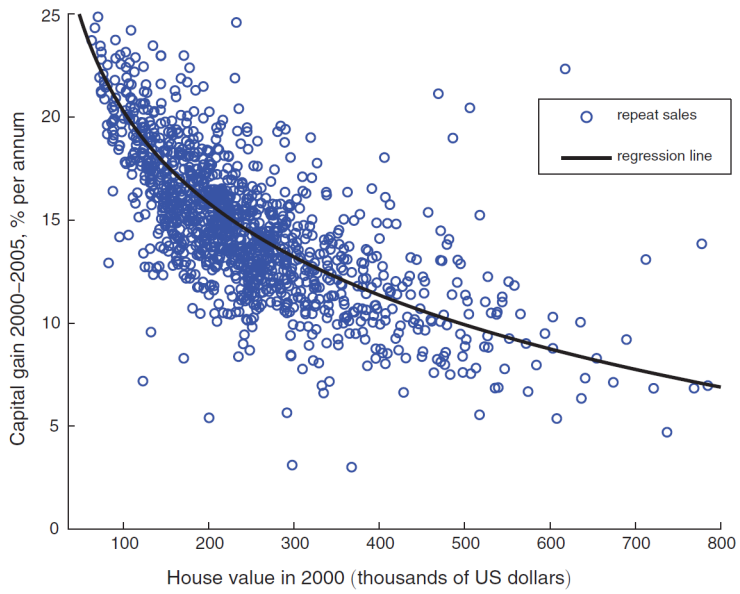


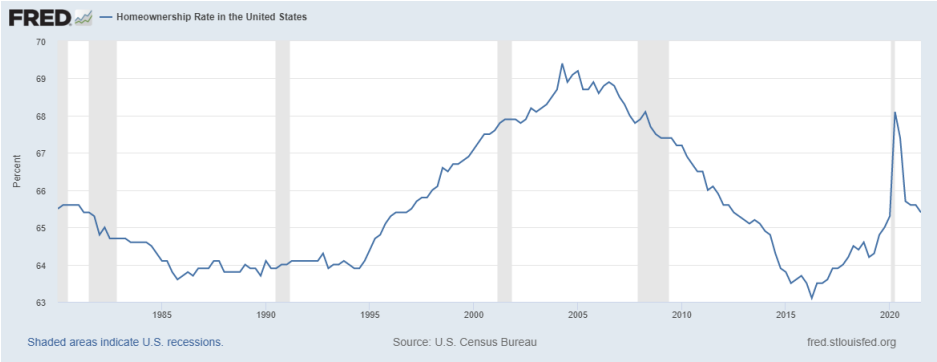
FIGURE 1. REPEAT SALES IN SAN DIEGO COUNTY, CA DURING THE YEARS 2000–2005

Notes: Every dot represents a residential property that was sold in 2000 and had its next sale in 2005. The horizontal axis shows the sales price in 2000. The vertical axis shows the real capital gain per year (annualized change in log price less Consumer Price Index (CPI) inflation) between 2000 and 2005. The solid line is the capital gain predicted by a regression of capital gain between 2000 and 2005 on the log price in 2000.

- Chodorow-Reich, Guren, McQuade (2021) argues long-run fundamentals explain the boom-bust-boom pattern in cross-section

2.1.3. Home Ownership

- Housing stock consists of owner-occupied housing, renter-occupied housing, and vacant housing (currently 7% vacancy rate)
- Home ownership rate shows boom-bust with little recovery
  - Ownership was around 45% from 1900-1940; increased after WW-II to 55% in 1950 (G.I. bill) and 62% in 1960, then roughly flat for 30+ years.
  - Increased from 63.8% in 1994.Q1 to 69.2% in 2004.Q2; this peak is two full years before the peak in house prices
  - Increase of 5.4% points represented 5 million more households owning their home. Stayed high at 68.9% until 2006.Q4
  - Started falling already in 2007: 67.8% in 2007.Q4, 67.5% in 2008.Q4, 67.2% in 2009.Q4, 66.5% in 2010.Q4, 66.0% in 2011.Q4, 65.4% in 2012.Q4, 65.2% in 2013.Q4, 64.0% in 2014.Q4, 63.8% in 2015.Q4, 63.1% in 2016.Q2.
  - Next three years, modest increase to 64.9% in 2019.Q4
  - Returning home ownership to the 1960-1995 average



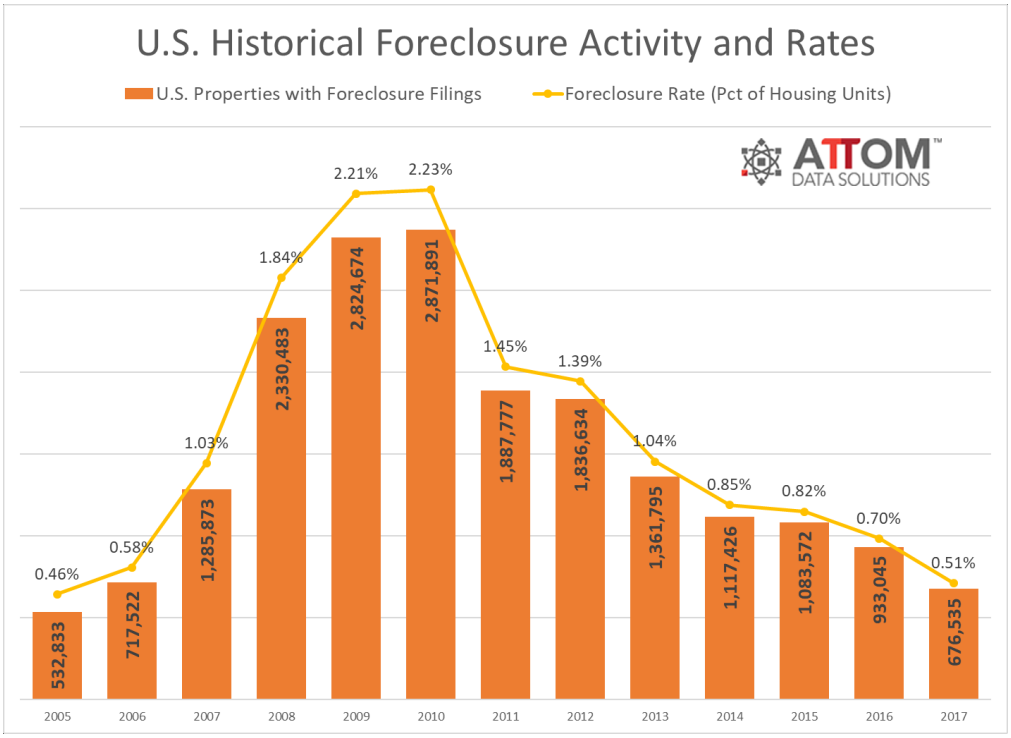
  - Big covid-19 bump to 68%. Could be seasonal adjustment? Or millennials rushed into suburban ownership?

  - Now back to 65.4% in 2021.Q3; gen-Zers came out of their parents' bedrooms back into renting? Renting as a necessity as house prices skyrocketed?

- Why did home ownership peak before prices did?
- What explains the very protracted fall in ownership, long after financial crisis was over?
- Why is there now a rebound?

2.1.4. Home Foreclosures

- About 8.9 million homes foreclosed from 2007.Q3-2019.Q3; those are completed foreclosures
- Foreclosure starts:

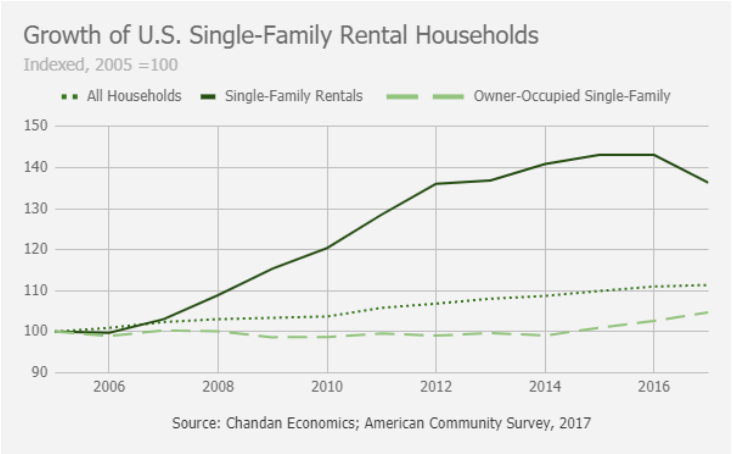


- Many of these foreclosed properties languished on banks' balance sheets as Real Estate Owned (REOs)
- Lots of state-level variation in length of foreclosure process due to judicial versus non-judicial foreclosure status (different from recourse vs. no recourse states)
- Government tried to stave off foreclosures through Housing Affordable Modification Program (HAMP), by incentivizing lenders to modify the mortgage, and Home Affordable Refinancing Program (HARP), letting home owners refinance even though they were under water. Total of 8.6 million "mods" over same period.

- Covid triggered a new wave of mortgage delinquencies. But due to foreclosure moratoria, the foreclosure rate actually fell to an all-time low. As foreclosure moratorium expires in Jan 2022, some uptick in foreclosures is expected but
  - house prices have risen a lot, restoring home equity so that defaulting borrowers can simply sell the property and pay off the mortgage
  - GSEs and banks have gotten much better at pro-active loan modifications.

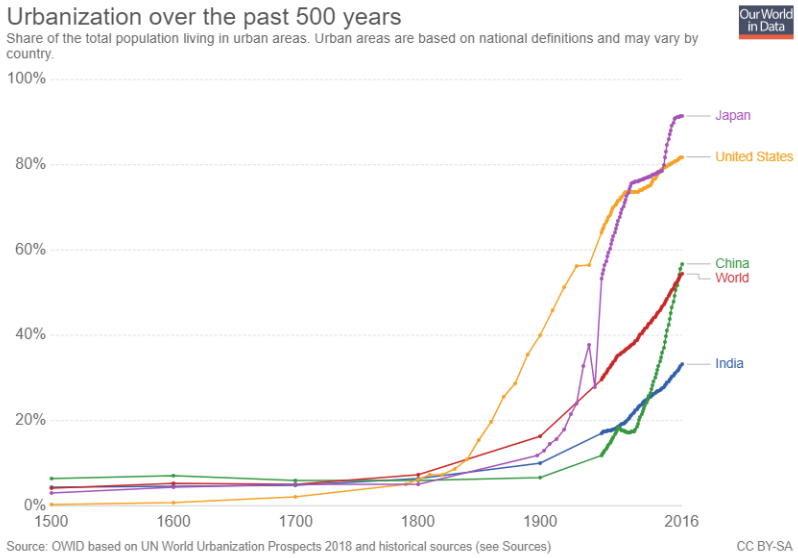
2.1.5. Multi-family vs. Single-family Housing

- Residential housing market consists of single-family housing and multi-family housing: 120.1 million occupied units in 2017
  - Owner-occupied housing units: 76.7 million
    - SF: 67.8 million
    - MF: 4.1 million
    - Other (mobile homes/RV/boats): 4.8 million
  - Renter-occupied housing units: 43.4 million
    - SF: 15.0 million
    - MF: 26.5 million
    - Other: 1.9 million
  - SF is 68.9% of housing stock, MF is 25.5%, other 5.6%
  - Most of the MF stock is rentals (86.5%), rest condos/coops
  - Most of the SF stock is owner-occupied (81.9%), but non-trivial share (18.1%) is SF rentals
  - Of all rentals, 34.5% are SF
  - SF rentals have grown from 11mi in 2005 to 15mi in 2017
- Data on housing units (number, type, characteristics of property and the household) is available from the Census Bureau at annual frequency and fine geography through its American Housing Survey and American Community Survey.



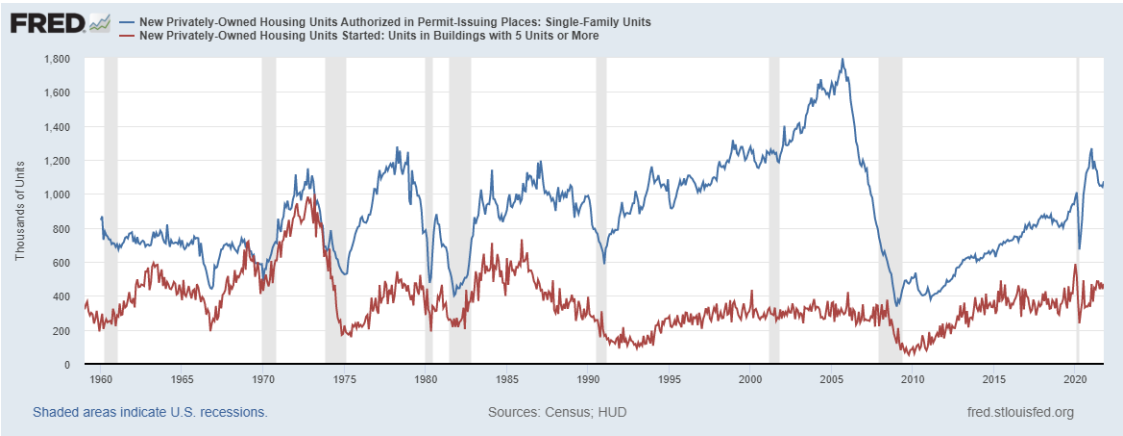
- In the financial crisis, private equity firms like Blackstone bought homes out of foreclosure, often at deep discounts, fixed them and started renting them out.
  - There has been a merger wave among SFR firms, with 2 large and 4 medium-size players remaining
  - Several have IPO'ed to access equity capital (combined market value about $20bi), following model of MF REITS
  - They also access public debt markets in form of SFR securitizations (face value about $20bi)
  - Still, professional ownership of SFR only represents about 200,000 homes or 1.35% of SFR housing stock
  - See Mills, Molloy, and Zarutskie (2017) and Demers and Eisfeldt (2018) for two academic papers on the topic
- There is a conversion margin between owner-occupied and renter-occupied units, but the conversion may incur a cost.

- MF units tend to be concentrated in urban areas while SF units tend to be more suburban.
- Urbanization trend worldwide suggests increased importance of MF.
  - In 2020, 55% of world population lives in urban areas. By 2050, that will be 68%. That's 2.5 bn more people in cities, mostly in Asia and Africa.
  - These areas have huge unmet modern property needs, both on the residential and commercial side.
  - Is the covid-19 induced flight to the suburbs a temporary blip in a rising urbanization wave or a trend reversal?



2.1.6. Residential Investment

- Construction of SF homes has been very slow since crisis, while construction of MF has been strong (renting/urbanization)



- Residential investment/housing permits/construction employment are the most volatile component of GDP, highly cyclical, and tend to lead the business cycle.
- That makes them an important time series for policy makers to follow and for economists to study.
  - Leamer (2007): Housing *is* the Business Cycle.
  - Recent slowdown in residential investment has economists worried.
  - But Ghent and Owyang (2010) find no consistent cross-sectional pattern between house price declines and employment declines at the MSA level
- Also, real estate is a durable asset with a life span of about 50 years; new construction only accounts for about 2% of the housing stock each year.

2.1.7. Return on Housing

- The housing return consists of HPA (price return) + rental yield (income return):

$$R^h_{t+1} = \frac{P^h_{t+1} + R_{t+1}}{P^h_t} - 1 = \left(\frac{P^h_{t+1}}{P^h_t} - 1\right) + \frac{R_{t+1}}{P^h_t} = HPA + RY$$

- Rental yield is a **large** component of the return. Difficult to measure precisely for owner-occupied housing since we do not measure the rent that owners pay to themselves (imputed rent). Easier for rentals.

- REITS are publicly listed real estate companies, which are required to pay out 90% of their taxable income to shareholders in order to avoid corporate income tax. They typically pay out 100%. Residential REITS' dividend yield may therefore be a good proxy of net rental yield.

  - All Resi REITS (1994.01-2020.11): Total return = 12.4%, income return = RY= 5.0% (40% of return)
  - Note that these are levered returns; REITS employ about 30% leverage. Delevering results in mean return of 8.7%.
  - REITS focus on stabilized properties in gateway housing markets. May not be representative of all of MF. Even less representative of SF housing returns.
  - Only SFR Resi REITS (3 firms, 2015.12-2021.09): 19.3% total, 1.7% income (income may be low b/c renovations). SFR REITS are a short time-series and small cross-section.

- Demers and Eisfeldt (2018) construct rental yields for 30 MSAs from 1986-2014 for renter-occupied properties.
  - On average across MSAs, total return is 8.9%; RY is 4.5% and HPA is 4.3%. Share of RY is 51% on avg.
  - Large CS variation in RY share of total return:
    * as low as 25% (San Francisco), 35% in other superstar cities (New York, Los Angeles), and as high as 74% (Oklahoma City).
    * Find that RY are 6.1% in lowest-price MSA quintile and 2.9% in highest-price MSA quintile.
    * HPA is 3.3% in low-tier cities and 5.3% in highest-tier.
    * Overall housing return similar: 9.4% in low-tier vs. 8.2% in high-tier.
- Giglio, Maggiori, Rao, Stroebel, and Weber (2021) construct total returns on SF housing, building on work by Favilukis, Ludvigson, and Van Nieuwerburgh (2017) [appendix to their 2010 working paper version.]
  - *Price-rent approach*: Start from initial price-rent ratio, then update using HPI and rental price index (CPI component), deflate by overall inflation.
  - *Balance sheet approach*: Obtain value of housing stock from national accounts (e.g., Flow of Funds) and data on housing consumption from national accounts (NIPA), adjust for growth in the quantity of housing
  - Gross housing return is around 9-10% per year
  - Net housing return subtracts depreciation and taxes and is around 6-7% per year.

Table IV: Expected Returns and Rental Growth

	United States										United Kingdom					Singapore
	Price/Rent					Balance Sheet					Price/Rent		Balance Sheet			Price/Rent
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Gross Return	10.3%	9.7%	8.9%	9.4%	10.0%	9.7%	9.3%	9.1%	8.9%	8.6%	9.5%	9.9%	10.3%	9.9%	9.7%	9.9%
Rental Yield	9.5%	8.9%	8.1%	8.9%	9.0%	7.1%	7.1%	7.0%	7.0%	7.0%	6.8%	7.2%	7.0%	6.9%	6.9%	5.6%
Capital Gain	0.8%	0.8%	0.8%	0.5%	1.0%	2.7%	2.3%	2.1%	1.8%	1.6%	2.7%	2.7%	3.3%	3.0%	2.8%	4.2%
Depreciation	2.5%	2.5%	2.5%	2.5%	2.5%	2.3%	2.3%	2.3%	2.3%	2.3%	2.5%	2.5%	2.4%	2.4%	2.4%	2.5%
Taxes	0.67%	0.67%	0.67%	0.67%	0.67%	1.1%	1.1%	1.1%	1.1%	1.1%	0%	0%	0%	0%	0%	0.6%
Net Return	**7.1%**	**6.5%**	**5.7%**	**6.2%**	**6.8%**	**6.3%**	**5.9%**	**5.7%**	**5.5%**	**5.2%**	**7.0%**	**7.4%**	**7.9%**	**7.5%**	**7.3%**	**6.8%**
Rent Growth	0.7%	0.7%	0.7%	0.7%	0.9%	-	-	-	-	-	1.4%	1.4%	-	-	-	-0.4%
Baseline-P/R	Trulia	Trulia$^-$	Bal	Trulia$^-$	Trulia$^-$	-	-	-	-	-	Bracke	Bal	-	-	-	iProp
Price Index	CS	CS	CS	FHFA	CS	-	-	-	-	-	LR	LR	-	-	-	URA
Rent Index	CPI-S	CPI-S	CPI-S	CPI-S	PCE-H	-	-	-	-	-	CPIH	CPIH	-	-	-	URA
Stock Adj.	-	-	-	-	-	Pop	Units	Floor	Reval	QI	-	-	Pop	Units	QI	-
Sample	1953-2016										1988-2016					1990-2016

Note: This table shows our estimates for net real returns to housing and real rent growth in the U.S., the U.K., and Singapore based on the price-rent approach and the balance-sheet approach. The *price-rent approach* starts from a price-rent ratio estimated in a baseline year and constructs a time series of returns by combining a house price index and a rental price index. Baseline-P/R is the source of the baseline price-rent ratio – either a direct estimate or based on the balance-sheet approach (Bal). In the U.S., Trulia$^-$ includes an adjustment for utilities possibly included in Trulia's gross rents. CS is the Case-Shiller house price index, FHFA is the FHFA house price index, CPI-S is the shelter component of the CPI, and PCE-H is the housing component of the PCE price index. In the U.K., LR stands for Land Registry, and CPIH is the consumer price index including housing. In Singapore, iProp stands for iProperty.com, and URA stands for Urban Redevelopment Authority. In the *balance-sheet approach*, the total value of the residential housing stock is used to estimate the value of housing, and net capital income earned on the housing stock is used to estimate net rents. To estimate the return on a representative property, changes in the total housing stock are controlled for by the growth in population (Pop), housing units (Units), housing floor space (Floor), or quality-adjusted quantity indexes (QI). The U.S. Financial Accounts also publish aggregate holding gains for each sector in the economy in the revaluation accounts (Reval), which directly hold the aggregate stock of housing constant. See Appendix A.4 for further details on the estimation procedures and the underlying data sources used. Numbers may not add up due to rounding.

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- Using *self-reported* home value data in the Panel Study of Income Dynamics for 1968-1992, Flavin and Yamashita (2002) also find housing returns with mean of 6.6% per year.

- Volatility of housing returns is difficult to measure. What we have is volatility of a housing return *index*.
  - The volatility of such an aggregate housing return is around 5-6% per year, resulting in a Sharpe ratio around 1.
  - But, this is not the return/SR to a tradeable strategy. One cannot easily buy well-diversified baskets of SF homes.
    - Except for SFR REITS; their Sharpe ratio over the short

2015.12-2021.09 sample (72 months) is 1.0 (19.3% return and 19.3% stdev)

- Moreover, house price indices suffer from *appraisal smoothing* which biases down volatility of aggregate housing returns; see literature started by Geltner (1991)
- Buying and selling individual houses incurs idiosyncratic risk, reflecting for example labor income risk in the neighborhood or risk of mismanagement of the local public schools
- Buying and selling individual houses also incurs large transaction costs, e.g. 6% broker fee (paid by the seller), mortgage recording tax, title insurance, etc.
- Some recent evidence on housing return volatility at the *property level* suggest volatility around 15%; see Flavin and Yamashita (2002), Landvoigt, Piazzesi, and Schneider (2002)
- Giacoletti (2021) shows that idiosyncratic housing return variance does not scale with holding period; higher for shorter holding periods. As a fraction of total housing return variance, idiosyncratic risk accounts for 80% for one-year holding period, but only 50% for ten-year holding period.
- Similar findings in **commercial** real estate transactions are found by Sagi (2021). Sagi proposes a matching model to capture illiquidity risk. Properties that must be sold quickly are exposed to more illiquidity risk.

- One traded proxy for the volatility of *aggregate* housing returns is the volatility of residential REIT returns, which is similar to the volatility of aggregate equity market
  * Resi REIT return volatility is 19.1% (1994.01-2020.11)
  * Income return volatility is only 1.1%; price return volatility is 19.1%.
  * After de-leveraging, we get to an *asset* return volatility of about 13.4%.
  * As noted, holdings of resi REITS are predominantly MF; stable, high-quality apartment buildings in first- and second-tier cities.
  * Some of the REIT volatility may be "inherited" from the broader stock market and reflect sentiment fluctuations; similar to discussion of "financialization" in commodities.
  * SFR REIT volatility is 19.3% but short sample (2015.12-2021.09), small cross-section, and emerging asset with large capital inflows.

2.1.8. The term structure of housing returns

- Giglio, Maggiori, and Stroebel (2015) ask whether the term structure of housing risk premia is upward or downward sloping; see literature on term structure for bonds, equities, and volatility
- They exploit a unique feature of housing markets in the UK and Singapore: There are both freehold and leasehold property rights.
  - Freeholds give full, infinite-horizon property rights
  - Leaseholds give long but finite-horizon property right, with initial leasehold maturities between 99 and 999 years.
- They observe that leaseholds trade at a substantial discount to freeholds, after controlling for all property characteristics

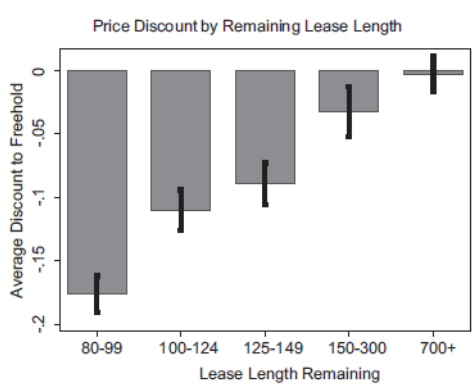


FIGURE I
U.K. Flats: Sample and Price Discounts

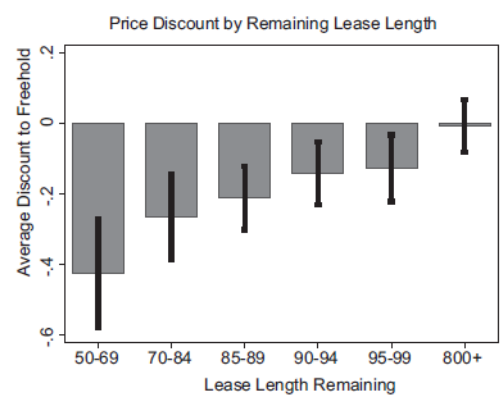


FIGURE III
Singapore: Sample and Price Discounts

- According to the Gordon Growth Model, the price difference between the T-period leasehold price and the freehold price is

$$\log(P_t) - \log\left(P_t^T\right) = (r - g)T$$

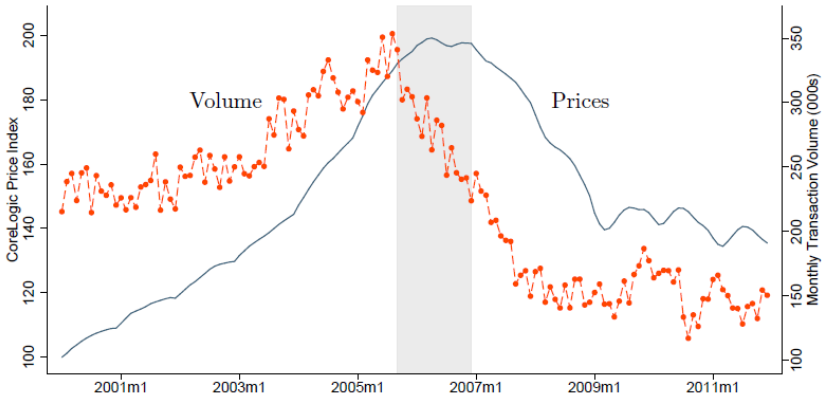
- A value for $r - g = 1.9\%$ fits the observed discounts very well.
- A value of $g = 0.7\%$ (or lower) is a good value for the long-run growth rate of real rents in the U.K. and Singapore data
- The leasehold/freehold discount implies that the very long-run expected return applied to cash flows hundreds of years into the future must be quite low, at most $r = 2.6\%$.
- If the very-long run real risk-free rate is about 1% per year, which seems like a reasonable guess from the TIPS data that are available for the U.K., then the housing risk premium is at most 1.6%.
- Therefore, if the average return on housing is about 6%, and the discount rate on rents more than 100 years into the future is about 2.6%, then the discount rate at the short end must be higher than 6%. The term structure of housing (excess) returns is downward sloping.
- These calculations can be informative to how to discount uncertain costs of *climate change* that occur hundreds of years into the future (Giglio, Maggiori, Rao, Stroebel, and Weber, 2020).

2.1.9. Volume and Time-on-the-market

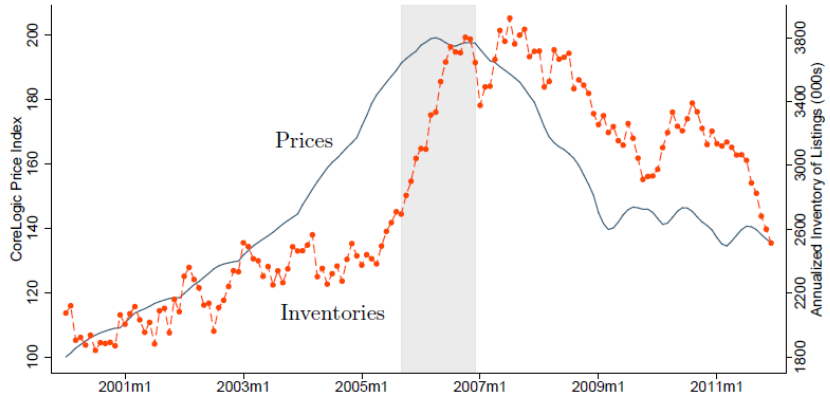
- Houses trade infrequently in illiquid markets
- House sales (transaction volume) are highly pro-cyclical
- In bad times, houses sell slowly and sit on the market for a long time, inventories accumulate (# months of supply)
  - This could be due to loss aversion by home owners, as in Genovese and Mayer (2001)
  - and/or due to home owners who are under water on their mortgage (Andersen, Badarinza, Liu, Marx, Ramadorai, 2021)
- Home sale cycle tends to lead the house price cycle, inventories lag the cycle.
- See the picture below from DeFusco, Nathanson, and Zwick (2021). This property is similar to other financial markets (e.g. NASDAQ around 2000).
- The longer selling times may amplify credit constraints, and lead to larger foreclosure waves in the bust (Hedlund, 2016).
- This illiquidity calls for models with search frictions, where it takes time to buy or sell a house. See review paper on search in housing markets by Han and Strange (2015).
- Investors (Bayer et al. 2020) and real estate brokers (Gilbukh and Goldsmith-Pinkham, 2019) may improve or exacerbate the illiquidity in housing markets.

The Dynamics of Prices, Volume, and Inventories

(a) Prices and Volume



(b) Prices and Inventories



Notes: This figure displays the dynamic relationship between prices, volume, and the inventory of listings in the U.S. housing market between 2000 and 2011. Panel (a) plots monthly prices and sales volume, and panel (b) plots monthly prices and inventory. Monthly price index information comes from CoreLogic and monthly sales volume is based on aggregated transaction data from CoreLogic for 115 MSAs representing 48% of the U.S. housing stock. Inventory information comes from the National Association of Realtors. We apply a calendar-month seasonal adjustment for both volume and inventories.

2.2. *Stylized Facts Mortgage Market*

2.2.1. Data sources

- Aggregate statistics: Urban Institute's Housing Finance at a Glance, updated monthly with lots of relevant statistics
- SIFMA for aggregate statistics on the securitization market
- Fannie Mae and Freddie Mac have made available a data set of loan-level mortgage data: loan characteristics and performance on own mortgages originated after 1999.
- Core Logic has data on private-label mortgages (expensive)
- HMDA has loan-level data on mortgage *applications* and loan and **borrower** characteristics for originations
- Equifax has household-level info on all sources of credit and credit card spending, which some researchers (at the Fed) have merged with mortgage data.

2.2.2. Size and Market Segments

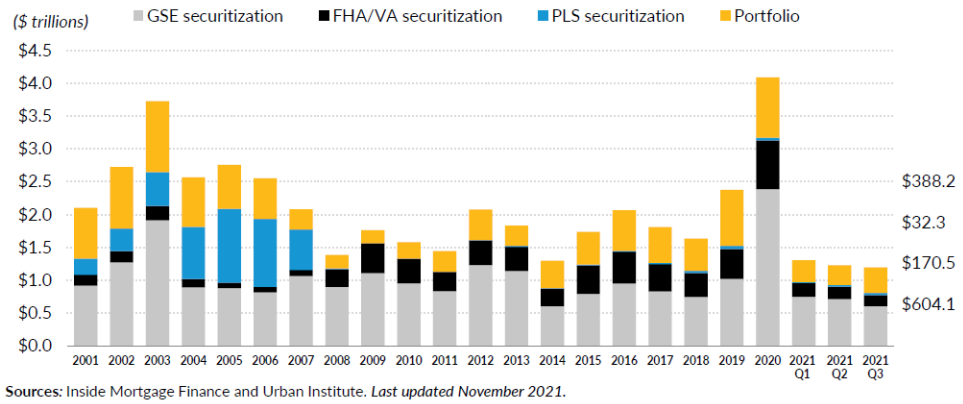
- Outstanding residential mortgage debt in U.S. is $12 trillion
  - $8.0tr (66.6%) is agency mortgage-backed securities market: Fannie Mae ($3.4tr), Freddie Mac ($2.1tr), and Ginnie Mae ($2.7tr).
  - $3.2tr (26.7%) is unsecuritized first liens on bank balance sheets, credit unions, and other non-depository institutions
  - $0.4tr (3.2%) is private-label MBS; including subprime, Alt-A, and jumbo
  - $0.4tr (3.4%) is second liens
- Ginnie Mae securitizes non-conventional (FHA/VA) mortgages.
  - FHA/VA mortgages themselves are already government-guaranteed (*ultimate* payment of principal and interest)
  - Ginnie Mae MBS enjoys additional government guarantee of *timely* payment of principal and interest
- Fannie and Freddie, the GSEs, securitize conventional, conforming mortgage loans
  - Mortgage principal below the conforming loan limit, $647,200 ($970,800 in high-cost areas) in 2022
  - Generally modest risk, as judged by combination of loan-to-value ratio (LTV), debt-to-income ratio (DTI), and credit score (FICO)
  - But credit risk accumulated in 1990s and 2000s (Acharya, Richardson, Van Nieuwerburgh, and White 2011)

  - After a period of very tight mortgage underwriting standards at the GSEs coming out of the GFC, the "credit box" is expanding again, due to, e.g., a new 3% down-payment program introduced in August 2018.
  - GSEs charge mortgage lenders a guarantee fee ("g-fee") to insure the default risk. Historically around 20bps, after GFC about 55bps.

- Agency MBS is second largest fixed income market in the world
  - $6.8 trillion To Be Announced (TBA) market is very liquid
  - Makes up 23% of Barclay's U.S. Aggregate Bond Index, a key benchmark for fixed income portfolio allocations
  - Daily trading volume of $320bn in 2010, compared to $500bn in Treasuries, $16bn in corporate bonds, $13bn in municipal bonds
  - Liquidity achieved by specifying only few loan pool characteristics (agency, maturity, interest rate); makes one pool *fungible* for another; cheapest-to-deliver pricing
  - Forward market, allows lenders to hedge warehousing risk
  - See Vickery and Wright (2013) for institutional details

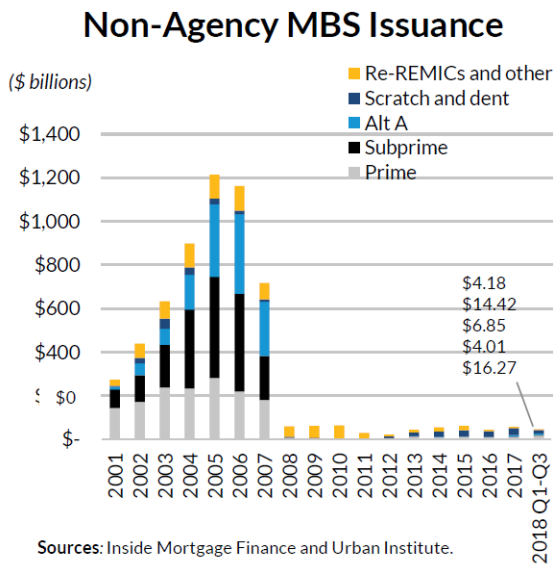
- Originations refers to the flow of new mortgage credit. About $2 trillion in new mortgages originated in U.S. each year. Both 2020 and 2021 were record years with $4 trillion in originations.

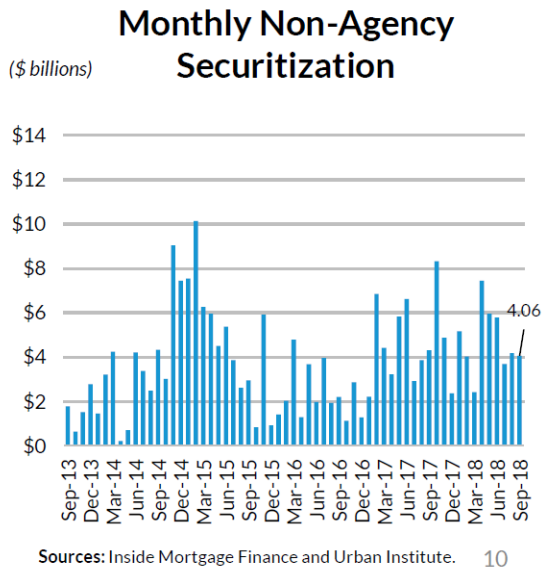
- Banks originate various types of mortgage loans: conforming loans, FHA/VA loans, and private loans that they hold on balance sheet, sell to the GSEs, or sell to a private-label securitizer.



- Mortgage market also broken down by purchase loans vs. loans for refinancing, by maturity, and by fixed-rate versus adjustable-rate (FRM/ARM)
  - More than 90% or purchase loans originated after 2008 are 30-year FRMs
  - A decent fraction of refis are 15-year FRMs
- ARM share fluctuates over time, fluctuations well described by difference between 10-year T-bond yield and the (backward looking) average of 3-month T-bill yield (Koijen, Van Hemert, and Van Nieuwerburgh, 2009). Households seem to be *timing* the mortgage market when choosing mortgage types.

- Private-label securitization (PLS) market gained large market share in 2003-07 at the expense of Fannie, Freddie, and especially FHA.
  - About $5 trillion in PLS issued; about half were ARMs
  - Originations disappear in 2007.H2
  - PLS market has been moribund since then





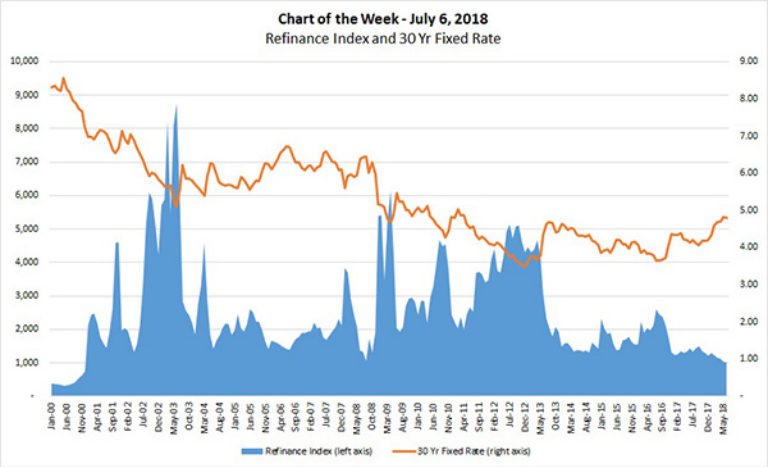
2.2.3. Holdings of Agency MBS

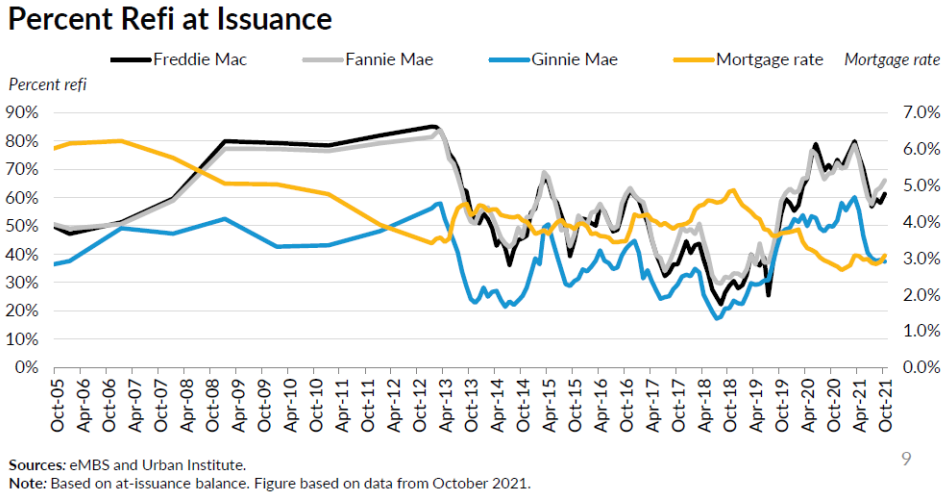
- \$10.7 trillion of Agency MBS + Agency debt (debt of GSEs) are broadly held:
  - depository banks (\$3.45tr)
  - Fed (\$2.59tr, *QE*)
  - foreigners (\$1.13tr)
  - mutual funds (\$0.66tr)
  - money mkt. funds (\$0.45tr)
  - life insurance (\$0.35tr)
  - households (\$0.2tr)
  - Specialized MBS investors quite small: mortgage REITS (\$167bn), broker-dealers (\$18bn). Caveat: hedge funds are included with households, but HH total is only \$201bn.

2.2.4. Prepayment Risk

- Since GSEs bear the default risk on conforming mortgages, the only risk left in agency MBS is not **whether** investors will be paid back, but **when** they will be paid back: prepayment or refinancing risk
- In U.S., conforming mortgage borrowers can prepay (partially or fully) their mortgage at any point in time without penalty. Borrowers have a put option to put the bond back to the lender.
- Prepayment risk is mostly an issue for FRMs.
- Sources of prepayment:
  - **Rate refis**: new FRM rate is below contract rate, mortgage balance not changed; driven by interest rates
  - **Cash-out refis**: goal is to take out home equity (LTV has fallen because HPA, relever property), even when rates rise; driven by house price growth
  - **Turnover**: job mobility; driven by strength of labor market, seasonality
  - **Default**: when borrower defaults, GSEs make principal payment, acts as prepayment for MBS investors
- Refi share of mortgage applications fluctuates dramatically, mostly with the history of interest rates
  - Burnout: refi wave is much larger when interest rates have been high for a while before coming down (e.g. 2003). If they go down further, not much additional effect since many have already refied (mortgage pool has "burnt out")

- Refi share very high in Oct 2021 at 65% at GSEs, 37% at FHA, as 30-yr FRM mortgage rates fall to 3.0%.



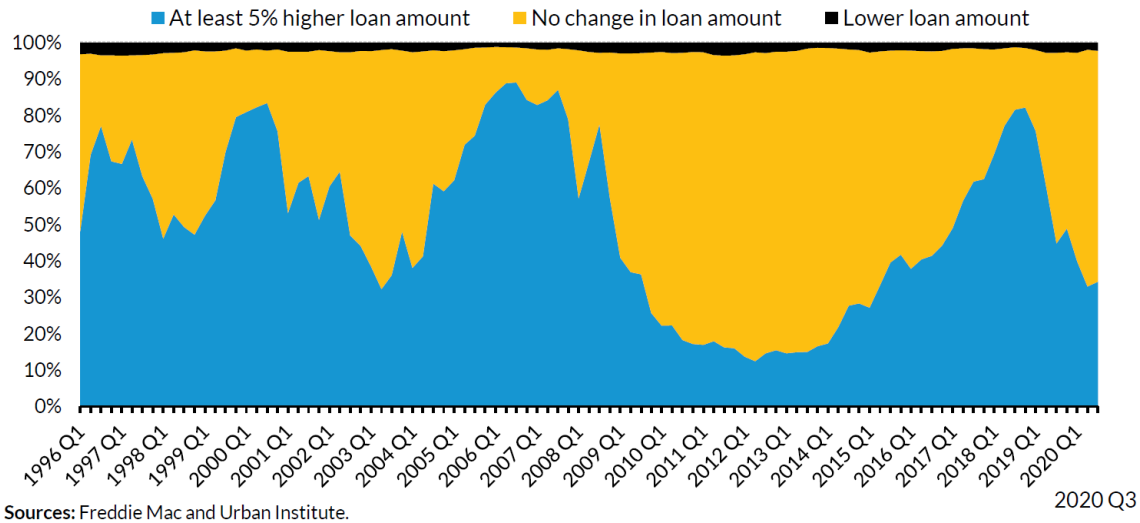


Sources: eMBS and Urban Institute.
Note: Based on at-issuance balance. Figure based on data from October 2021.

- Cash-out refis were enormous during boom; households took on $1.25 trillion in additional mortgage debt, much of it was consumed, artificially boosting the macro-economy in 2004-06, and contributing about 40% of the mortgage defaults.

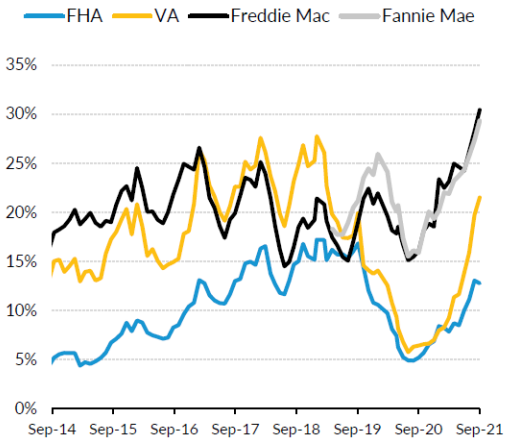
- Recently cash-out refi share rising again and pumping about $60bn in additional resources into the economy quarterly.

Loan Amount after Refinancing



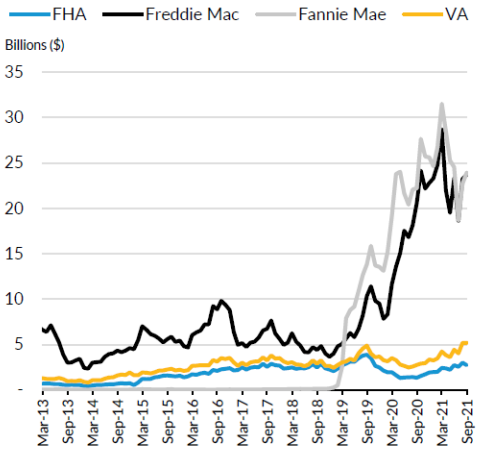
Sources: Freddie Mac and Urban Institute.
Note: Estimates include conventional mortgages only.

Cash-out Refi Share of All Originations



Sources: eMBS and Urban Institute.
Note: Data as of September 2021.

Cash-out Refinance Volume by Agency



Sources: eMBS and Urban Institute
Note: Data as of September 2021.

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- Prepayment speed expressed as annualized fraction of monthly mortgage balance B_t that prepays, the Constant Prepayment Rate or CPR (annualizes the single-month mortality or SMM)

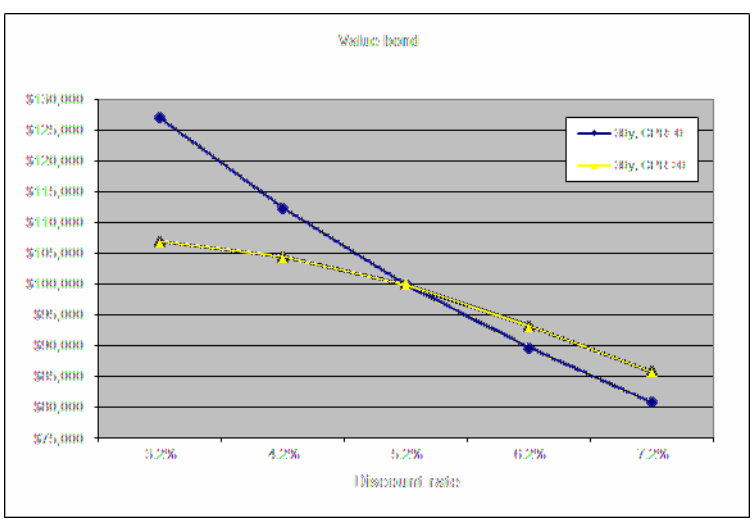
$$\begin{aligned} SMM_t &= 1 - \frac{B_t}{B_{t-1}} \\ CPR_t &= (1 - SMM)^{12} - 1 \end{aligned}$$

- Usually, we assume that CPR "ramps up" linearly in first 30 months of the life of the mortgage since people don't tend to refi when they just got a new mortgage (costly to do so)

- CPR of 15% is about average

- 30-year FRM with rate of 5.2% (with ramp-up) and CPR=15% has MacCaulay duration D of 5.0 years.

  - At 5% CPR, $D = 8.12$; at 25% CPR $D = 3.7$.
  - Recall duration measures the interest rate risk of a bond
  - MBS have "negative convexity": a reduction in rates increases value of the MBS much less than that of a Treasury bond because of prepayments (which come in at par)



- The first-order determinant of prepayment speed is the rate incentive or moneyness, measured as the mortgage rate (coupon rate on the MBS + 50bp) minus the current 30-yr FRM rate

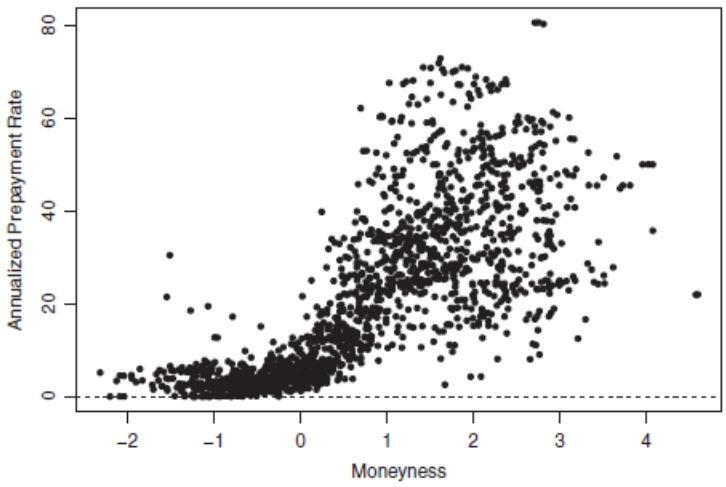


Figure 2
Prepayment rates for FNMA mortgage-backed securities
This figure plots the 3-month prepayment rates for FNMA mortgage-backed securities against the moneyness of the mortgage-backed securities. Moneyness is expressed in percentage points. The prepayment rates are expressed as annualized percentages of the outstanding principal balance of the mortgage-backed security. The data consist of monthly observations for all liquid coupons over the January 1998 to September 2014 sample period.

- Prepayment rates fluctuate a lot over time (vintage), holding fixed the moneyness

- As mentioned, other factors that drive prepayment are interest rate history (burnout), home equity (house prices), credit score (investor sophistication), state of the economy (job mobility or defaults), changes in lending standards, ...

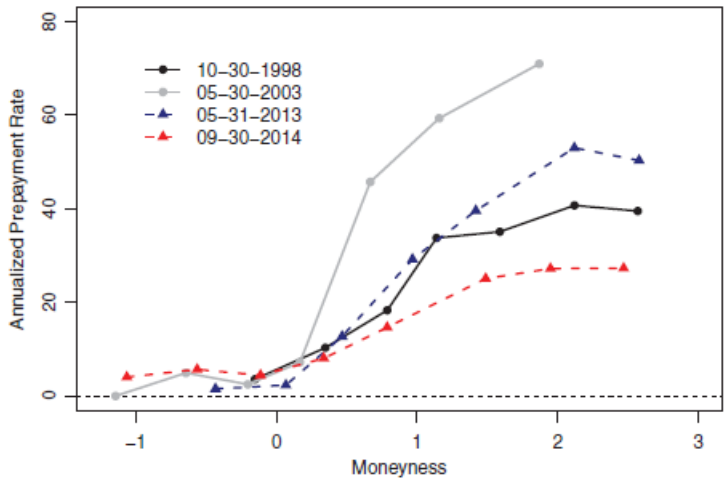
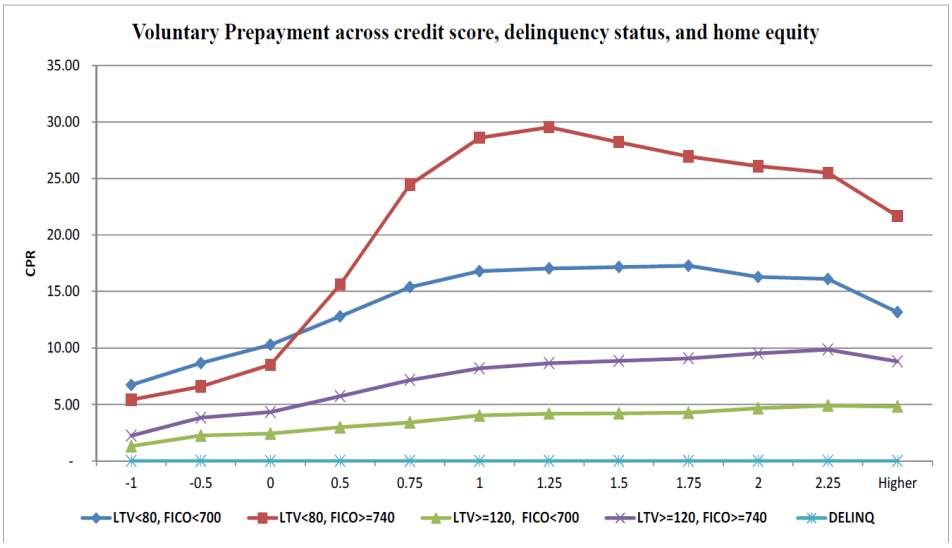


Figure 3
Prepayment rates for FNMA mortgage-backed securities for selected dates
This figure plots the 3-month prepayment rates for FNMA mortgage-backed securities against the moneyness of the mortgage-backed securities for the indicated dates. Moneyness is expressed in percentage points. The prepayment rates are expressed as annualized percentages of the outstanding principal balance of the mortgage-backed security.



- Can express value of a MBS in terms of its option-adjusted spread (OAS). Akin to expressing option prices in terms of their implied volatility.

- OAS is the adjustment needed to make the price of the MBS, observed in the market, equal to the PDV of payments using an interest rate risk model and a prepayment function that depends only on interest rates:

$$P_0 = \frac{1}{I} \sum_{i=1}^{I} \sum_{t=1}^{T} \frac{C_{i,t}}{\prod_{s=1}^{t} (1 + f_{i,s} + OAS)^t}$$

  where i indicates the interest rate path (I Monte Carlo simulations) and $f_{i,t}$ is the forward swap rate for month t on interest rate path i. The cash-flow $C_{i,t}$ contains scheduled payments of principal and interest, as well as *prepayments driven by rates*.

- High OAS securities are cheap: they have high yields after accounting for interest rate risk and rate-driven prepayment risk.

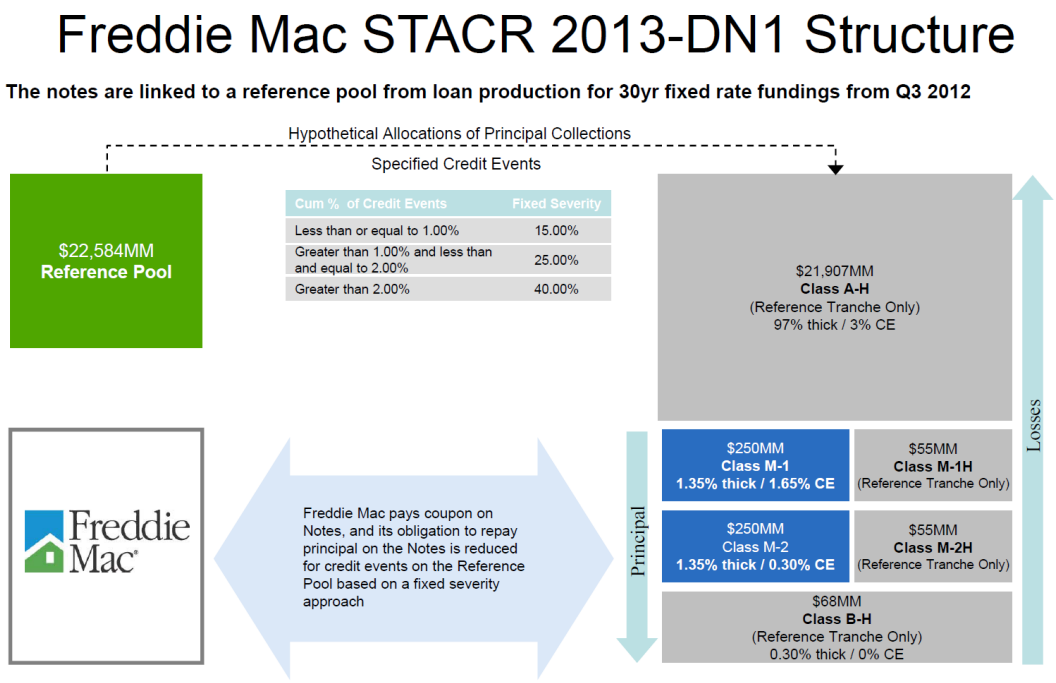
- Interpretation: OAS is compensation for all **non-rate driven sources of prepayment risk**, OAS is sometimes called the "pure prepayment risk" premium.

- OAS also includes any liquidity premium on MBS and any credit risk premium associated with the government guarantee

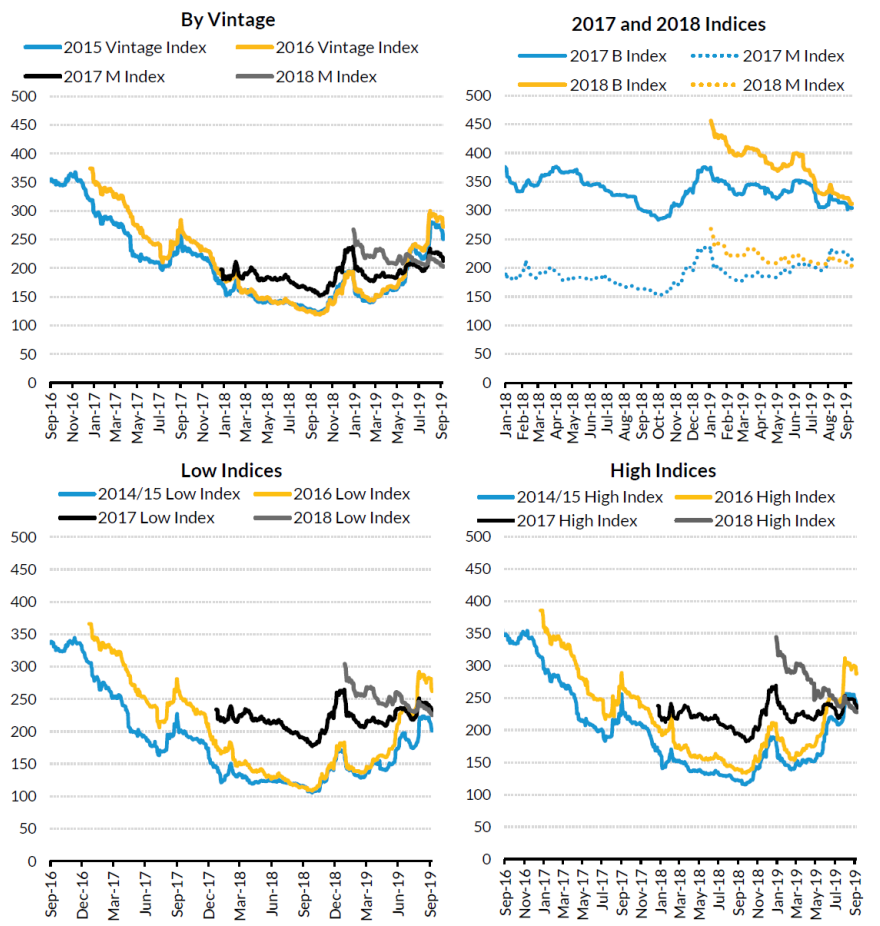
- Below, we discuss a literature that has modeled this pure prepayment risk.

2.2.5. Credit Risk Transfers

- Fannie and Freddie have increased their guarantee fees from 20bps before the crisis to 55bps after the crisis
  - Higher cost of default insurance has led banks to retain a larger share of mortgages loans on balance sheet
- GSEs have made a ton of profit since 2010, which enabled them to pay back the $188bn bailout from the GFC era. The Treasury department has now received $300bn, implying a 11% IRR for the taxpayer on the bailout "investment."
- Constant calls for re-privatization of GSEs ever since conservatorship began in Sep 2008. Reaching fever pitch in last days of Trump administration. Biden administration poured cold water on the Fannie and Freddie IPOs.
- Important policy question: what is the right level for the guarantee fee?
- In 2013, the GSEs started selling off some of the credit risk in so-called Credit Risk Transfer deals (STACR and CAS).
- Over the past 7 years, Fannie & Freddie have "re-insured" credit risk on $3.9 trillion of mortgage loans by issuing $100bn of CRT bonds. These CRT bonds have become a sizeable mortgage credit risk market, which is under-studied in academia.



- Some details on CRT bond market
  - Initially GSEs only sold off the mezzanine credit risk: loss rates between 0.3% and 3.0%. Loss rates on worst agency MBS vintage (2007) were about 3.0%.
  - Later vintages also sold off the first-loss piece (loss rate from 0-0.3%) and some of the catastrophic risk piece (loss rate between 3% and 5%).
  - Initially the collateral was all low-LTV loans (80% or lower), later they started selling off credit risk on higher-LTV loans
  - Technically, CRT bonds are unsecured corporate debt of Fannie and Freddie, 5-year maturity



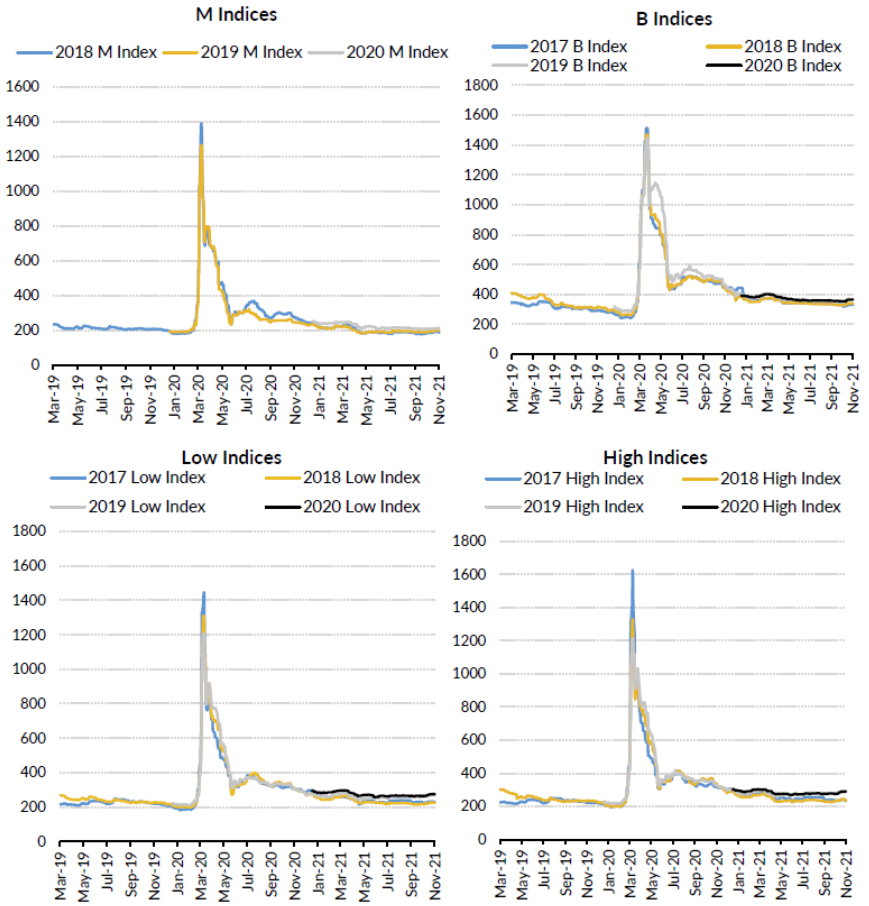
Sources: Vista Data Services and Urban Institute.
Note: Data as of September 13, 2019.

- The yields they pay investors on the CRT bonds could **inform level of the g-fees**. That explicit connection has not happened yet.

- Interesting question is what is the *optimal* degree of pass-through from CRT yields to g-fees. GSE policy as mortgage market stabilization policy tool?

- With covid-19 crisis CRT spreads widened dramatically in March 2020. Markets anticipated a major mortgage market meltdown with large losses. Prices of CRT bonds fell, spreads rose. In such a scenario, GSEs would receive billions in "default relief" thanks to CRT bonds.

- After govt. intervention, spreads came back down. Now seems unlikely that CRT bond holders will suffer major credit losses.



Sources: Vista Data Services and Urban Institute.
Note: Data as of November 16, 2021.

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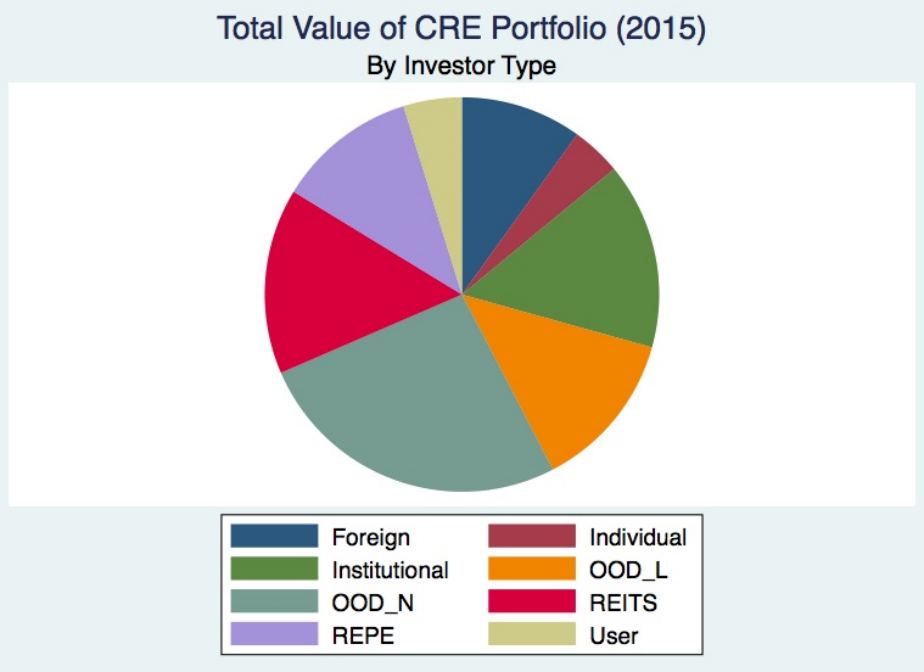
2.3. Stylized Facts Commercial Real Estate Market

- Commercial real estate is divided in 4 major sectors and a few smaller sectors:
  - **Office**: CBD/suburban
  - **Retail**: shopping malls, strip centers
  - **Industrial**: warehouses, medical labs
  - **Apartments**: highrise, garden apartments
  - Other: Hospitality (hotels, casinos, entertainment), student and senior housing, data centers, cell phone towers
- Data sources. REIT data are easily available, but REITs only cover 10-15% of transaction volume and holdings of CRE. There are lots of CRE data sources on asset-level transactions, but data are notoriously expensive and messy. That has hindered research in commercial real estate.
  - NCREIF: data crowd-sourced from large institutional asset managers. High quality assets in gateway markets, goes back to mid 1970s, accessible at low cost for research.
  - Real Capital Analytics: CRE price indices, sales by type and geography, market analysis, transaction-level data with property characteristics, and identity of buyers and sellers
  - Core Logic: commercial data in addition to residential data
  - Costar, REIS: lots of transaction and property level data
  - Compstak: very good leasing information crowd-sourced from CRE brokers
  - Start-ups: Reonomy, Lavamap, ATTOM, PropertyShark

- Commercial Real Estate Data Association (CREDA) is trying to improve data access for faculty and PhD students, but it is a slow process...
- Institutional-grade commercial real estate is broadly held by many different types of investors
  - Foreign investors (esp. from China and Canada)
  - Institutions like banks and insurance companies
  - REITS
  - Owner-operator-developers (Local, or National)
  - Real estate private equity funds
  - End users like non-financial firms, non-profits, govmt.



- Koijen and Van Nieuwerburgh (2022) develop a demand-based asset pricing model of the CRE market exploiting the transaction-level data from RCA containing the identity of buyers and sellers.

2.3.1. Equity REITS

- About 15% of CRE assets are held by equity REITS, publicly listed vehicles.
  - Total market cap of $1.0 trillion in 2018 in 186 companies.
  - Another 40 REITS worth $67bn are *mortgage REITS* and excluded since they hold MBS rather than property.
- That 15% often serves as a *benchmark* for the privately-held 85%.
  - But REITS are levered (about 30%)
  - May not hold a representative portfolio, in terms of geography (tilted towards "gateway" markets), risk (hold "stabilized" assets), and asset quality (hold "class A" assets)
  - May be contaminated by "noise" in the stock market (like the financialization of commodities discussion)
- Like residential real estate, commercial RE assets trade infrequently in "OTC" transactions and assets are heterogeneous. This makes it hard to come up with "the market price" or "the (expected) return" for CRE assets
- Open question is how to best calculate the risk (variance and covariance with other traded assets such as stocks and bonds) for infrequently-traded private commercial (or residential) real estate. Index providers like MSCI Barra are very interested in this question and spend significant effort on answering it.

2.3.2. Equity REIT return and risk

- Van Nieuwerburgh (2018) studies equity REITS for 1972-2016 (full sample) and 1994-2016 (modern REIT sample) using factor models

Table 1 ■ Analyzing equity REIT performance: unconditional factor models.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	A: Full Sample 1972–2016					B: Modern REIT Sample 1994–2016				
α	3.12	2.92	−0.65	−0.09	−1.02	2.90	1.87	−1.11	−0.60	−1.82
t-Stat	1.43	1.34	−0.32	−0.04	0.54	0.77	0.48	−0.34	−0.18	−0.58
β^s	0.66	0.66	0.69	0.67	0.69	0.74	0.77	0.79	0.75	0.82
t-Stat	9.37	9.16	10.44	10.59	12.10	5.54	5.80	7.77	7.28	9.01
β^b		0.09	0.20	0.21	0.18		0.31	0.44	0.48	0.43
t-Stat		0.93	2.93	2.64	2.16		1.44	2.78	3.05	2.64
β^{smb}			0.41	0.41	0.45			0.44	0.45	0.49
t-Stat			7.72	7.90	8.41			5.46	5.59	5.44
β^{hml}			0.57	0.55	0.59			0.73	0.69	0.68
t-Stat			6.40	6.39	4.50			6.27	6.15	3.79
$\beta^{mom/op}$				−0.06	0.17				−0.10	0.16
t-Stat				−1.18	2.27				−1.45	1.41
β^{inv}					−0.07					0.00
t-Stat					−0.51					0.02
R^2	36.58	36.75	52.25	52.56	52.82	32.54	33.61	52.17	52.85	52.47
Exp. ret.	8.16	8.36	11.93	11.36	12.29	7.20	8.24	11.21	10.70	11.93

Note: The dependent variable is the excess return on the equity REIT index. The independent variables are listed in the main text. The first row reports the intercept α, the other rows report risk factor exposures β. The t-statistics are computed using Newey–West standard errors with one lag. The last but one row reports the R^2 of the regression. The last row reports the expected return according to the regression model. It includes the risk-free rate and excludes the alpha. The data are monthly from January 1972 to December 2016 in Panel A and from January 1994 to December 2016 in Panel B.

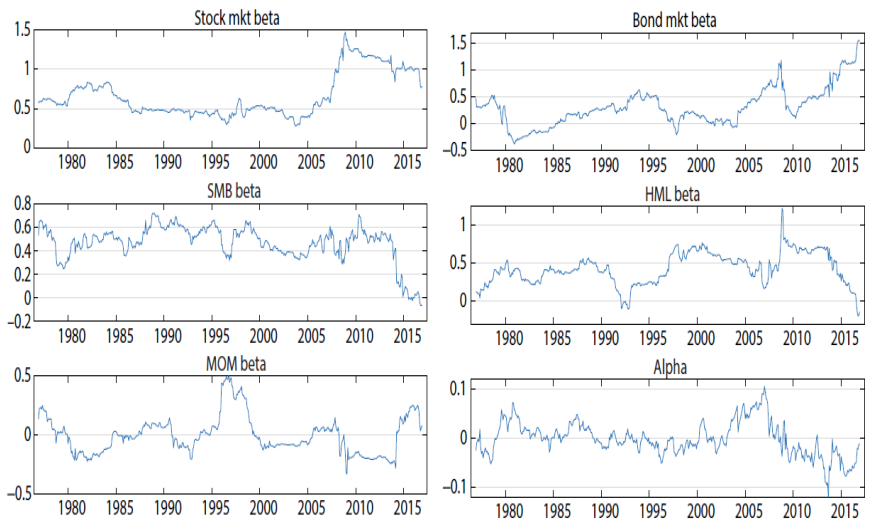
- REITS behave like small value stocks. Three-, four-, or five-factor FF models explain 52% of variation; zero alpha.
  Expected return is about 12% per year, reflecting REITS' different sources of systematic risk exposure.

- Form expected returns on REITS based on the 5-factor model, using 60-month rolling-window betas and full-sample lambdas

$$x_t = E_t\left[r_{t+1}\right] = r_t^f + \beta_t^s \Lambda^s + \beta_t^b \Lambda^b + \beta_t^{smb} \Lambda^{smb} + \beta_t^{hml} \Lambda^{hml} + \beta_t^{mom} \Lambda^{mom},$$

- Main findings:
  - Stock market risk of REITS was very high in last decade
  - Bond market risk of REITS is at all-time high
  - Small stock and value stock risk has receded

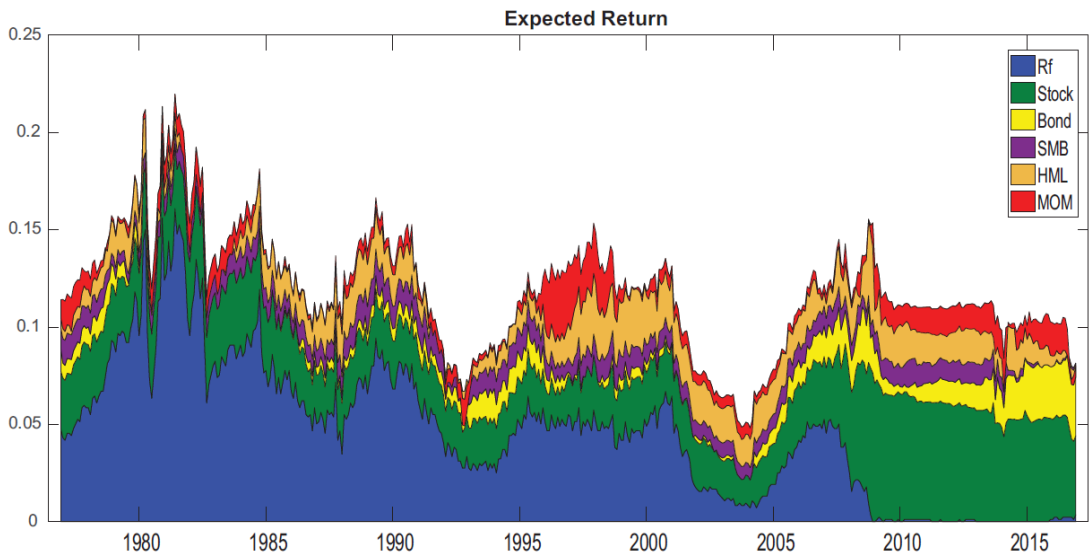
Figure 5 ■ Time-varying betas for REITS in five-factor model. [Color figure can be viewed at wileyonlinelibrary.com]



Notes: The figure plots the exposures (betas) of equity REITS to five risk factors: the stock market, the 10-year bond market return, the size (SMB) factor, the value (HML) factor and the momentum (MOM) factor. The figure also displays the abnormal return or alpha. In each month, the risk-factor exposures and the alpha are estimated from a multivariate regression using the most recent 60 months of data. The sample period is January 1972–December 2016.

- Despite reduction in risk-free rate after 2009 (ZLB), expected return of REITS has increased due to increased stock and bond market risk.
- This implies that the expected return was *not* unusually low after 2009.

Figure 6 ■ Expected return of REITS in five-factor model. [Color figure can be viewed at wileyonlinelibrary.com]



Notes: The figure plots the expected return on REITS as implied by the five-factor model in Equation (16). The betas on the factors are estimated on 60-month rolling windows. To calculate the risk premium, we multiply each beta with the average excess return on the factor over the full 1972–2016 sample.

- But REIT price/dividend ratio was very high from 2010-2016.
- Therefore, investors must have believed that future dividend growth was very high.
- How high? Note that long-run average dividend growth on REITS is 5.6% per year (in nominal terms)

- We can use Campbell-Shiller to back out implied current and future expected dividend growth

$$pd_t - \overline{pd} = E_t\left[\sum_{j=1}^{+\infty} \rho^{j-1}\left(\Delta d_{t+j} - \bar{g}\right)\right] - E_t\left[\sum_{j=1}^{+\infty} \rho^{j-1}\left(r_{t+j} - \overline{x}\right)\right].$$

- Assume AR(1) for expected dividend growth

$$g_t \equiv E_t[\Delta d_{t+1}]$$

$$g_t = (1-\rho_g)\overline{g} + \rho_g g_{t-1} + \varepsilon_t^g$$

$$E_t\left[\sum_{j=1}^{+\infty} \rho^{j-1}\left(\Delta d_{t+j} - \overline{g}\right)\right] = \frac{1}{1-\rho\rho_g}(g_t - \overline{g}).$$

Likewise assume an AR(1) for x_t

$$x_t = (1-\rho_x)\overline{x} + \rho_x x_{t-1} + \varepsilon_t^x \tag{1}$$

Then implied expected dividend growth is

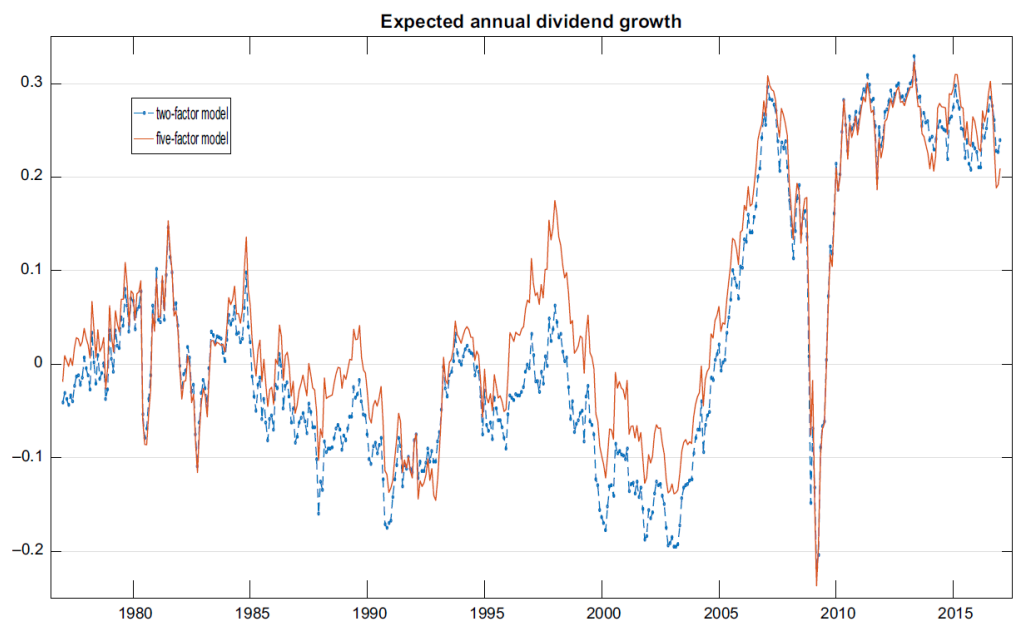
$$g_t = \overline{g} + (1-\rho\rho_g)\left(pd_t - \overline{pd}\right) + \frac{1-\rho\rho_g}{1-\rho\rho_x}\left(x_t - \overline{x}\right). \tag{2}$$

- With the observed time series for the pd ratio and the estimated time-series for the expected return from the five-factor model, we can compute expected dividend growth g_t for empirically plausible values of (ρ, ρ_g, ρ_x).

- Figure shows that investors expected 20% annual dividend growth going forward, or using the AR(1) for g_t, cumulative dividend growth was expected to exceed the long-run average by 55%.

- REITS did underperform the stock market after mid-2016, as suggested by the paper.

Figure 7 ■ Implied expected dividend growth. [Color figure can be viewed at wileyonlinelibrary.com]



Notes: The figure plots the expected dividend growth rate g_t, implied by the observed demeaned price-dividend ratio and the expected return per Equation (10). The dashed line is for the two-factor model and uses x^{2f} while the solid line is for the five-factor model and uses x^{5f}. The long-run expected growth rate $\overline{g}$ differs across models since the long-run expected return differs and the mean price-dividend ratio is the same.

3. Models to Explain the Facts

- There is one older literature in macro on the role of housing in business cycle models. The housing-augmented RBC models can generate volatile residential investment but not volatile house prices. See Davis and Van Nieuwerburgh (2015, section 3) for an extensive summary of the literature.

- There is another older literature, a branch of the portfolio choice literature in finance, that studies households consumption-savings decisions and risky-riskless portfolio allocation in partial equilibrium. This literature studies life-cycle patterns in

  - home ownership
  - overall wealth (net worth) accumulation
  - stock ownership, and risky stock share conditional on stock ownership
  - mortgage debt, and sometimes mortgage choice (FRM/ARM, HELOC)
  - for realistically calibrated labor income risk, house price risk, and stock market risk (and their *cross-correlations*)

  See Davis and Van Nieuwerburgh (2015, section 4) for an extensive summary of that literature.

- We will focus here on the asset pricing literature. See Davis and Van Nieuwerburgh (2015, section 5) for an extensive summary.

3.1. Structural asset pricing models of housing returns

3.1.1. CCAPM

- Consumption-CAPM with CES aggregator over housing and non-housing consumption goods

$$U(C_t, H_t) = \frac{\tilde{C}_t^{1-\gamma}}{1-\gamma}, \quad \text{where } \tilde{C}_t = \left(\chi C_t^{\frac{\varepsilon-1}{\varepsilon}} + (1-\chi) H_t^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}},$$

  where χ is the weight on non-housing consumption and ε in the elasticity of substitution between C and H.

- The log SDF m_{t+1} can be written as the product of the standard single-good factor and a new factor that captures the composition effect:

$$m_{t+1} = \log \beta - \gamma \Delta c_{t+1} + \frac{1-\varepsilon\gamma}{\varepsilon - 1} \log\left(\frac{1+R_{t+1}}{1+R_t}\right)$$

  where $R_t = \frac{C_t}{\rho_t H_t}$ is the ratio of non-housing to housing expenditure, with ρ_t equal to the rental price of a unit of housing.

- A special case of these preferences is $\varepsilon = 1$, in which case the CES aggregator becomes Cobb-Douglas. In that case, households optimally spend a fixed proportion on both consumption goods and the ratio R_t is constant at $\chi/(1-\chi)$. The new term in the SDF vanishes and we are back to the one-good Lucas-Breeden economy with its problematic asset pricing predictions.

- Piazzesi, Schneider, and Tuzel (2007) consider values for ε strictly greater than, but close to one (housing and non-housing consumption are substitutes). This choice makes the coefficient in front of the second term negative and large in absolute value.

That means that an asset whose return is low when growth in the total expenditure to housing expenditure ratio $1 + R$ is low is risky and carries a high return.

- For more empirically plausible choices of ε around 0.3-0.7 (housing and non-housing consumption are complements), the second term in the SDF creates too little action.

3.1.2. Housing Collateral-CAPM

- Lots of empirical evidence that households borrow against their house when faced with a negative income shock, and when they have spare debt capacity. This prevents or mitigates a decline in consumption.
  - See Hurst and Stafford (2004), Campbell and Cocco (2007), Ejarque and Leth-Petersen (2008), Hryshko et al. (2010), Lustig and Van Nieuwerburgh (2010), DeFusco (2018), and Sodini, Van Nieuwerburgh, Vestman, and von Lilienfeld-Toal (2021)
- In other words, households cannot perfectly insure their idiosyncratic labor income risk because markets are incomplete. However, when housing collateral is abundant, markets are less incomplete than when housing collateral is scarce.
- Lustig and Van Nieuwerburgh (2005) build an asset pricing model of this housing collateral effect. The SDF that comes out of the model:

$$m_{t+1} = \log \beta - \gamma \Delta c_{t+1} + \frac{1 - \varepsilon\gamma}{\varepsilon - 1} \log \left(\frac{1 + R_{t+1}}{1 + R_t} \right) + \gamma \Delta \log \xi^a_{t+1}$$

- New third term $\gamma \Delta \log \xi^a_{t+1}$ measures the extent to which housing collateral constraints bind in the economy.[1]
- The housing collateral effect is operative even when preferences are separable between housing or non-housing consumption or when the aggregator is Cobb Douglas.
- Main effect:
  - When lots of households become constrained, which happens when housing collateral is scarce, $\Delta \log \xi^a_{t+1} >> 0$, the SDF spikes. We are far from perfect insurance.
  - When no agent's housing collateral constraint binds, when housing collateral is abundant, $\Delta \log \xi^a_{t+1} = 0$, and we are back to the Lucas-Breeden full insurance world.
  - The economy moves between more and less risk sharing with the value of the housing stock
- This is a conditional C-CAPM, where the housing collateral scarcity is the conditioning variable.

[1] Specifically, ξ^a_{t+1} is a cross-sectional moment of individual ξ^i_{t+1}s. The latter are cumulative Lagrange multipliers on the housing collateral constraint. They increase from their time-t value when agent i's constraint binds at $t+1$, and stay constant otherwise.

- Housing collateral model implications:
  - SDF prices cross-section of equity portfolios: small and value stocks have low returns exactly when housing collateral is scarce; also some success on momentum portfolios.
  - Cash-flow channel: Dividends on value firms fall after a decrease in housing collateral
  - Housing collateral ratio predicts aggregate stock market return in the time series
  - Generates downward sloping term structure of returns
  - Direct evidence from regional income and consumption data that the amount of risk sharing varies over time, with the housing collateral ratio. See Lustig and Van Nieuwerburgh (2010).

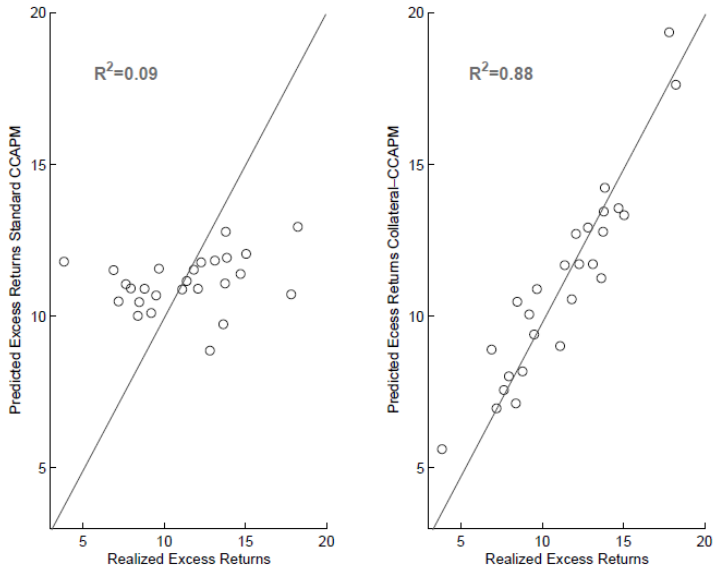


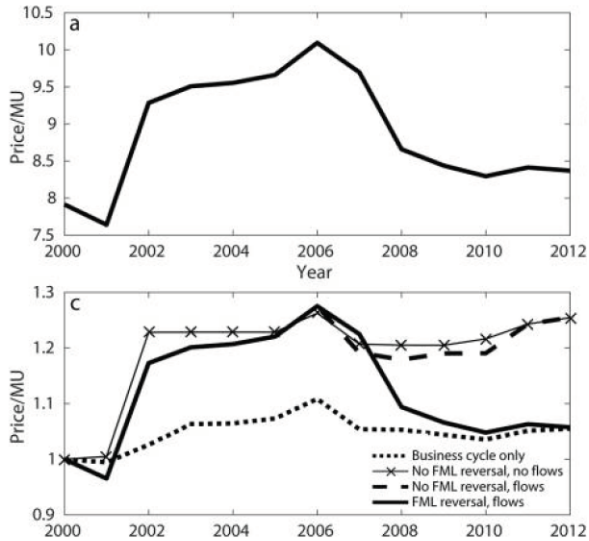
Figure 7. Realized versus predicted returns: The consumption-CAPM and collateral-CAPM. Left panel: Realized average excess returns on 25 Fama–French portfolios and the value-weighted market return against predicted excess returns by standard consumption-CAPM. Right panel: Against predicted returns by collateral-CAPM (under separability).

3.1.3. The Great Recession

- A large literature in macro-finance has explored the role of housing in the Great Recession. See Davis and Van Nieuwerburgh (2015, section 6) for an extensive summary.
- One key challenge is to explain the large boom and bust in house prices, which standard macro-housing models fail to account for.
- Favilukis, Ludvigson, and Van Nieuwerburgh (2017) shows that you can generate the observed magnitude housing boom (aggregate price-rent ratio increase of +30%) in an incomplete markets model. The boom (2001-07) is a combination of three ingredients:
  - Mortgage lending standards relaxed (max LTV increases)
  - Positive economics shocks (TFP)
  - Foreign demand for U.S. safe assets
- Also accounts for a substantial fraction of the bust (P/R -18%) via tightening of mortgage lending standards and negative TFP shocks, even in the absence of mortgage default.
- Model is quantitatively consistent with the observed
  - *Life-cycle patterns* in income, housing wealth, net worth, and consumption.
  - *Inequality* patterns in labor income, housing wealth, and financial wealth, and their evolution over the boom-bust period (realistic gini coefficients are important for the results)

- *Unconditional asset pricing moments*: equity risk premium and housing risk premium, as well as a low and fairly stable risk-free rate
- *Conditional AP moments*: Equity return, housing return, and dividend growth predictability
- *Construction* is endogenous.
- Since the *mortgage lenders* in the model are the rich households, they are risk averse and subject to the same relaxation of lending standards during the boom.

- Vast influx of safe assets had little impact on house prices
- TFP shocks alone do not generate enough action in house prices



- Model with product innovation and mortgage default: Corbae and Quinten (2015)

- Greenwald (2018) studies the interaction of debt-to-income (DTI) and loan-to-value (LTV) constraints and how they affect monetary policy transmission.
  - Emphasizes the importance of a relaxation in DTI constraints to explain boom in U.S. house prices.
  - Such constraints were relaxed in part through lack of income verification in the mortgage underwriting process (NINJA loans)
- Kaplan, Mitman, and Violante (2020) extend the FLVN (2017) model to include a rental market and long-term mortgages.
  - Emphasize the need for shocks to beliefs about house price growth in addition to relaxation of credit constraints to explain joint dynamics of home ownership, leverage, and house prices.
  - However, they also fundamentally change the rental market and how financial constraints apply to landlords/investors.
  - Some direct evidence on house price expectations is brought to the analysis. But hard to find support for specific form of HPA beliefs that is needed for the model to work.

- Greenwald and Guren (2021) show that the modeling of rental markets is critical for importance of expansion/contraction of credit for the housing boom/bust.
  - Assuming perfect segmentation between rental and owner-occupied housing leads to large effects of credit on house prices.
  - Assuming frictionless rental markets makes credit irrelevant for house prices, only for home ownership.
  - Relative elasticity of the price-to-rent ratio and home ownership w.r.t. an identified credit shock is a sufficient statistic to measure the degree of segmentation.
  - Data suggest strong segmentation, and thus large role for credit expansion/contraction story.
- There is a parallel debate between the role of credit supply relaxation and (irrational) beliefs on the empirical side, mostly in corporate finance
- The buildup of mortgage debt among vulnerable households is seen as having exacerbated the severity of the recession.
  - An influential research agenda by Mian and Sufi (2009, 2011, 2014) studies the connection between the buildup of subprime debt and home equity extraction in the boom, which they view as a shift in the supply of credit, and subsequent mortgage defaults, employment losses, and consumption declines in the bust.
  - More evidence that credit supply relaxation was important is in Favilukis, Kohn, Ludvigson, and Van Nieuwerburgh (2012), Favara and Imbs (2015), a review by Mian and Sufi (2017), and Cox and Ludvigson (2019).

- This research agenda is not without controversy. Adelino, Schoar, and Severino (2013, 2016) argue that the middle class received a lot of the mortgage debt during the boom, including via exotic mortgages. They argue that this suggests a broad increase in demand for mortgage debt, maybe driven by broadly-shared optimistic beliefs about future house price growth.

- Question of whether there was an expansion in credit supply or in credit demand remains unsettled. Note that both credit constraints and beliefs are endogenous. It will ultimately be impossible to point to a single trigger event/shock that "caused" the housing boom and bust.

- Enormous literature on the mortgage crisis documenting the roles of

  - misalignment of incentives along the securitization chain
  - credit ratings agencies (Griffin and Tang, 2011)
  - misstatement of asset or borrower quality [appraisal, owner occupancy status, presence of silent second liens, income and asset documentation/verification]; Piskorski, Seru, Witkin (2015), Griffin and Maturana (2016), Mian and Sufi (2017), and Kruger and Maturana (2021)
  - negative amortization (Amromin, Huang, Sialm, Zhong, 2018)
  - race to the bottom with GSEs (Acharya, Richardson, Van Nieuwerburgh, and White, 2011)
  - investors (Chinco and Mayer, 2015, Bayer et al. (2020), DeFusco, Nathanson, and Zwick, 2017)
  - securitization for foreclosure and modification (Kruger, 2018)

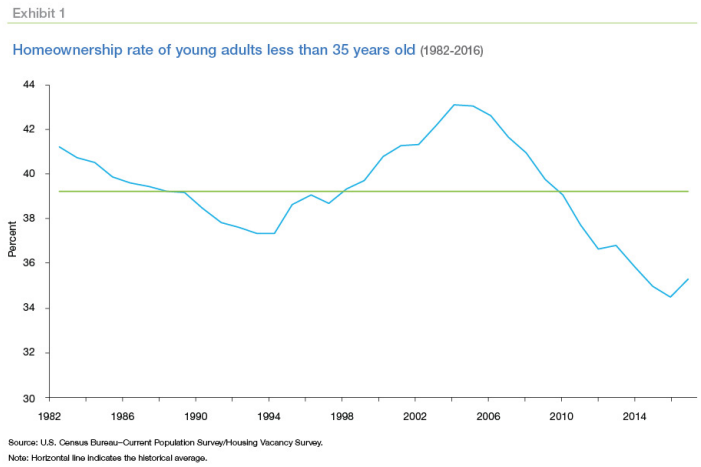
- See Keys, Piskorski, Seru, and Vig (2013) for a review of non-prime mortgages and private-label securitization

- A deeper discussion of these issues takes us away from empirical asset pricing...

- With financial crisis a decade old, focus in research has shifted towards the slow housing market (and broader economic) recovery from 2010-2016, and the role of tight mortgage underwriting standards.

  - Gete and Reher (2018) argue that mortgage credit supply contracted, and this led to lower home ownership, larger demand for rental housing, and higher rents (+2.1%).

  - How do mortgage lending standards compare to weak job market, student debt, preference for renting as explanation for reduction in home ownership among millennials?



- Goodman and Mayer (2018) study home ownership across time and countries and show that U.S. is falling behind (after adjusting for demographics)

- Mabille (2020) studies house prices in a regional business cycle model with endogenous mobility. Emphasizes the role of first-time buyers for boom-bust dynamics. Studies importance of millennials' student debt and graduating in recession.

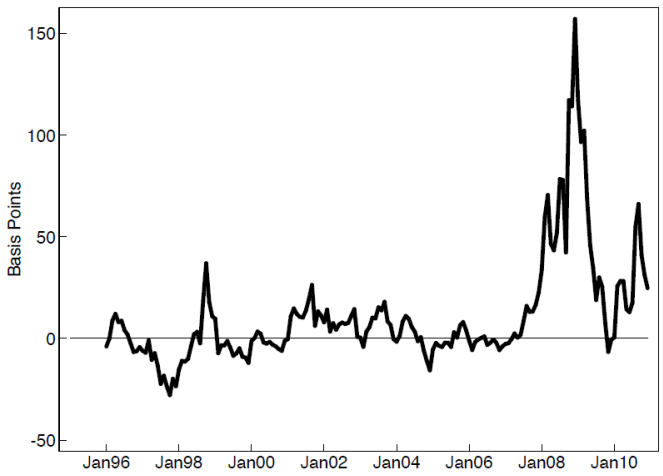
- Favilukis, Mabille, and Van Nieuwerburgh (2021) study the issue of affordable housing in a model with city center and suburbs, and evaluate policies such as rent stabilization, zoning changes, mandatory inclusionary housing, moving affordable housing out of the city center, etc.

3.2. Explaining MBS Returns

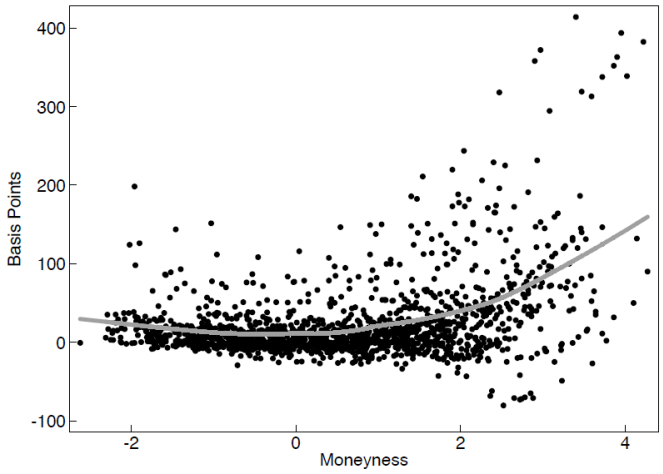
- Older literature thinks of MBS pricing as American put option valuation problem. MBS investors are short this prepayment option since home owners decide when/whether to exercise their option to prepay.
  - Akin to zero OAS assumption
  - Started with Schwartz and Torous (1989)
  - Deng, Quigley, and Van Order (2000) study interaction of prepayment and default options
  - Limited empirical success since households display sub-optimal prepayment behavior and/or many prepayments are unrelated to rates (Andersen et. al. 2020)
- Recent literature studies the **pure prepayment risk premium**, compensation for systematic prepayment risk not captured by interest rate movements.
- Boyarchanko, Fuster, and Lucca (2019) study variation over time and across securities in the OAS
  - Sort MBS by coupon = moneyness of the prepayment option. High coupon relative to current mortgage rate means prepayment option is in-the-money.
  - Find a smile in cross-section of both OAS and average excess returns: OTM and ITM securities have higher risk premia and Sharpe ratios than ATM securities.

Figure 2: Time-series and cross-sectional variation of the OAS based on dealer TBA data. The top panel displays the time series at monthly frequency of the option-adjusted spread (to swaps) on a value-weighted index based on TBA quotes from six dealers. The bottom panel displays a scatterplot and a local smoother of the cross-sectional variation in the OAS across MBS coupons as a function of their moneyness. Moneyness is calculated as the coupon rate plus 50 basis points (to account for servicing and the guarantee fee) minus the 30-year fixed-rate mortgage rate obtained from Freddie Mac. The figure only includes coupons with remaining principal balance of at least 100 million in 2009 dollars. All data is as of month-end and covers the period 1996-2010. Further details on the construction of the value-weighted series is reported in Section 3. Appendix B.1 discusses the sample in more detail.

(a) **Time series**



(b) **Cross section**



- OAS predicts future realized MBS returns after rate risk is hedged out, making it a good candidate proxy for the pure prepayment risk premium:

$$r_{t+1}^{hedged} = OAS_t - D_t \Delta OAS_{t+1}$$

(a) Hedged returns and OAS

	(1) 1-year	(2) 1-year	(3) 1-month	(4) 1-month	(5) 1-month	(6) 1-month
OAS	1.36***	1.41***	1.75***	1.95***	0.50*	1.15***
	[0.21]	[0.13]	[0.63]	[0.61]	[0.28]	[0.27]
ΔOAS					-2.37***	-2.33***
					[0.30]	[0.25]
Month FEs?	No	Yes	No	Yes	No	Yes
Adj. R2	0.19	0.70	0.02	0.53	0.56	0.78
Obs.	1990	1990	2076	2076	2064	2064

- Realized returns also (and mostly) depend on realized changes in OAS, multiplied by duration.

- Diep, Eisfeldt, and Richardson (2021) use realized excess returns on cross-section of MBS returns sorted on moneyness.
  - Also find smile in risk premia in cross-section of MBS sorted by moneyness.
  - Argue that this smile results from a composition effect: sometimes risk premium curve is decreasing in moneyness; at other times it is increasing
  - Linear two-factor model does a good job explaining the XS of average returns (after rate risk is hedged out).

$$E_t\left[r_{t+1}^{hedged,i}\right] = \lambda_{x,t}\beta_x^i + \lambda_y \beta_y^i$$

    * First factor, x, is a level factor, shifting prepayments on all coupons up and down.

    * Second factor, y, is a rate sensitivity factor, measuring how sensitive prepayment is to rates, for a given incentive

- Show that sign of the pure prepayment risk premium, $\lambda_{x,t}$, changes depending on whether overall MBS market is ITM (MBS trade at a premium, most coupons are higher than current rates) or OTM (discount market).
- Argue that this change in MPR sign is evidence that specialized MBS investors/intermediaries are the marginal agents. They are risk averse and have limited prepayment-risk bearing capacity.
    * When the overall MBS market is ITM, a positive shock to prepayments is bad news for the wealth of the intermediary since prepayments destroy value (prepayments come in at par): $\lambda_x < 0$
    * When the overall MBS market is OTM, a positive shock to prepayments is good news for the wealth of the intermediary: $\lambda_x > 0$
    * Idea that marginal agent is an intermediary in MBS market in Gabaix, Krishnamurty, and Vigneron (2007)
- Comment 1: It is hard to estimate an unconditional risk premium based on a short sample. It is harder still to estimate a conditional risk premium. The average realized return over a short sub-sample may not be a good proxy for the conditional risk premium.
    * Changes in OAS are negatively correlated with realized (hedged) returns
    * Changes in mortgage rates change the moneyness of securities, moving MBS securities along the smile.

    - For an OTM MBS, increase in rates increases OAS and leads to lower hedged returns. For an ITM MBS, increase in rates result in lower OAS and higher realized returns.
    - Maybe the β_x of the securities change sign with rates, rather than the market prices of risk λ_x?
    - Consistent with this explanation, BFL find that there always is a smile in OAS and excess returns: in premium and in discount markets.
  - Comment 2: MBS are incredibly broadly held, far beyond the broker-dealer or specialized MBS investor sector (recall holdings). Most institutional investors hold MBS alongside Treasuries, corporate bonds, municipal bonds, making it unlikely that these markets are segmented.
    - Would be useful to estimate different price elasticities of demand for MBS investors a la Koijen and Yogo.
    - Presumably very low for Fed and foreigners.
- Chernov, Dunn, and Longstaff (2018) find important role for credit and liquidity risk in MBS pricing, and for turnover-driven prepayment. Use a broader cross-section of MBS. Estimate the model based on pass-through MBS.

4. House Prices as Signals of Climate Risk

4.1. Two Functions

- Climate change features two critical "functions"
- First function maps economic activity, via CO_2 emissions, to temperature increases
- Second function maps temperature changes (and the associated sea level rise, flooding, hurricane and forest fire frequency and intensity) to economic damages
- First function is the domain of scientists; many models ranging from the fairly simple DICE models to very complex, non-linear models of the global climate system.
- Economists can be more useful with helping to understand the second function, known as the damage function
- Investing in climate mitigation technology trades off a certain current cost against an uncertain future benefit
  - Traditional **risk** of future benefits of mitigation = risk of future damages from climate change
- But there is also substantial uncertainty about the two functions
  - Economists have developed tools to quantify **model uncertainty** (e.g., Knight; Savage; Heal and Millner, 2014; Barnett, Brock and Hansen, 2020)

4.2. *Right Discount Rate?*

- Discount rates need to reflect both the horizon and the risk of the future damages (or equivalently of the benefits from mitigation)
- Since the damages occur far into the future, correct discount rate is crucial for viability of mitigation investments
- Nobel laureate William Nordhaus proposes a 4% discount rate, the average rate of return on physical capital
- But this investment has neither the same horizon nor the same risk profile as climate mitigation technology
- Real estate is a good asset to infer the discount rate because
  1. It is a long-lived asset (more so than physical capital)
  2. It is exposed to climate change: sea level rises (SLR), floods, hurricanes, forest fires all reduce the value of the asset
     - 6 feet SLR would flood 6mi homes worth $1 trillion (Rao, 17)
  3. Exposure to climate risk is heterogeneous (e.g., by elevation, distance to the coast, inside/outside flood zones)

4.3. *Empirical Challenges*

- House prices reflect a whole host of characteristics of the structure and the location, not just climate risk exposure
- Proximity to coast (beach access) is valued as amenity, increasing prices, but also increases exposure to SLR and flooding risks, lowering prices. Which force dominates?

- Prices only reflect climate risk if average buyer believes in it Bernstein, Gustafson, and Lewis (2019)
  - Selection may drive people who love the beach and/or are not worried about climate change to the coastal areas.
  - Believers can sell to deniers, mitigating the price effect Bakkensen and Barrage (2021)
  - Or we get separating equilibrium with some coastal enclaves full of climate deniers and others full of climate believers
- Insurance, if it underprices risk or blunts cross-sectional dispersion in risk, blurs price signal in housing markets
  - Only 3% of the U.S. population has flood insurance; only 30% of households in high-risk areas (100-year flood plain), despite insurance mandate in those areas
  - Most of the insurance is provided by FEMA, usually at subsidized rates (history of the NFIP).
  - Because of increasing awareness and growing risk exposure, there is a nascent private flood insurance market.

4.4. Empirical Approach

- Identify a set of properties that have greater exposure to climate risk (treatment group) than others (control group),
  - Based on property's elevation level or location in flood zone
- Argue that climate change awareness/salience/beliefs changes discretely due to some precipitating event
  - Major flood, like hurricane Sandy, or wild fires in West
  - Major policy change, like redrawing of FEMA flood maps or change in flood insurance like 2012 Biggert-Waters Act
  - Mentioning of climate change in text of real estate listings (Climate Attention Index)
- Study the change in house sale transaction prices in the treatment group relative to the control group in the period after the change compared to before (difference-in-differences approach)
- Only valid if property prices in the treatment and control group evolved similarly in the "pre period" (parallel pre-trends)

4.5. Findings

- Bernstein, Gustafson, and Lewis (2019)
  - Homes exposed to SLR risk trade for 7% lower prices than homes equidistant to beach and otherwise similar
  - Discount has been growing over time
  - Largely due to sophisticated investors and second home buyers
- Baldauf, Garlappi, and Yannelis (2020)
  - House prices in areas with higher proportion of climate change believers are more sensitive to climate risks
  - A house located in a flood zone sells for 2.9% less than an identical house located outside a flood zone
  - Discount is 1.0% greater for every 1% increase in the fraction of households believing in climate change
- Giglio, Maggiori, Rao, Stroebel, and Weber (2021)
  - A 1% increase in the Climate Attention Index, an index based on text in real estate listings, lowers property prices by 0.3%
  - A doubling in the Climate Attention Index lowers property prices in the flood zone by 2.4% points more than outside flood zones

- Gibson, Mullins, Hill (2020) study NYC and three changes
  1. Biggert-Waters Act (which increases insurance premiums) decreases NYC home sale prices by 1.7%
  2. Sandy flooding decreases house prices by 8-13%
  3. New floodplain maps for properties that did not flood during Sandy lowers prices by 18% $\Rightarrow$ belief updating
- Murfin and Spiegel (2020)
  - Property's elevation should be valued more highly in areas expecting faster SLR (*net* SLR actually because land mass rises in some places)
  - Finds SRL risk not capitalized into real estate prices (precisely estimated null effects)

4.6. Back to Discounting

- On balance, evidence shows that houses are long-lived assets whose values are sensitive to climate risk
- Giglio, Maggiori, Rao, Stroebel, and Weber (2021) propose a disaster framework and argue that climate disasters are bad states of the world

  $\Rightarrow$ investors are willing to pay a high price for technologies and insurance that avoid the disasters or their consequences (hedge the risk)

  $\Rightarrow$ the uncertain future benefits of climate mitigation technology should be discounted **at very low rates**, below the term structure of risk-free interest rates, below 1-2% per year.

- This is the opposite view from that the DICE models of Nordhaus, where high-damage states are good states of the world with fast GDP growth and high emissions

  $\Rightarrow$ climate mitigation technologies pay off in good states of the world and should be discounted more heavily

4.7. Role of intermediaries

- Tomunen (2021) studies catastrophe bond market and how pricing of climate risk changes after natural disasters. Uses intermediary-based asset pricing model like Gabaix, Krishnamurty, and Vigneron (2007) and Diep, Eisfeldt, and Richardson (2021) since there are only a few key intermediaries in cat bond market for natural disasters.

- RFS has special issue on Climate Finance in March 2020, with many more interesting contributions to the finance of climate change.