Debt Rollover in Rental Housing

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Abstract

This paper studies how changes in landlords' mortgage financing costs affect rental housing. Using a novel dataset linking property-level asking rents, mortgages, and financial outcomes, I exploit quasi-exogenous variation in mortgage contract terms coming from the expiration of prepayment lock-out periods. I find that landlords significantly raise revenue by 3% at refinance, even where mortgage payments decline. Occupancy rates rise, then asking rents on new tenants rise. These effects are heterogeneous with respect to mortgage rate exposure and mark-to-market LTV. The results imply landlords adjust on multiple margins, suggestive of frictions or lumpy costs in pricing behavior and leasing.

Keywords: Rental Housing Markets, Real Estate Economics, Mortgage Finance, Behavioral Pricing.

JEL Classification: R31, G21, D22, D25, D83, E44

*Email: samuel.hughes{at}ofr.treasury.gov. This paper is a revised version of my dissertation. Please find the earlier draft and Online Appendix at my website: https://sites.google.com/view/skhughes/research. The content is the responsibility of the author. I thank Benjamin J. Keys, Jessie Handbury, Joe Gyourko, Todd Sinai, Philip Mulder, Tom Cui, Jacob Sagi, and Joe Nichols for their advice and comments, as well as the Wharton Applied Economics Workshop, UNC KFBS Finance, OFR, FHFA, FTC, and CFPB Seminars, and participants at the Federal Reserve Bank of Philadelphia's Mortgage Market Research Conference and AREUEA National Conference. I also appreciate the efforts of Erin Timko at Trepp, as well as Victor Samuel and Carla DeMarzo-Sanchez at REIS and Moody's for their assistance using the data in this project.

1 Introduction

Do landlords pass along any of the benefits from lower financing costs to their tenants? While many homeowners and landlords benefited from refinancing into mortgages with progressively lower rates over the past two decades, it is unclear whether tenants have shared in those benefits. Over the same time period, median rent-to-income ratios rose from 25% to 30% so that in 2017 half of renter households spent more than 30% of their income on rent (JCHS 2020), generating concerns about a rental housing affordability crisis. Understanding how monetary policy decisions and changing interest rates affect renters—who make up 35% of the U.S. population, have lower average incomes, and are more likely to be from minority groups—is informative about how monetary and macroprudential policy affect the real economy. This paper studies whether and how shifts in debt financing costs on multifamily mortgages affect tenants, landlord behavior, and rental housing markets.

Providing causal evidence on these issues is difficult because financing costs are (1) capitalized into a property's value, (2) endogenously linked to granular geographic changes in neighborhood amenities and labor markets, and (3) likely to simultaneously affect property quality and operations. The first concern is that interest rates, and financing costs more broadly, are causally linked to or systematically correlated with property values.[1] A second, related concern is that properties in neighborhoods experiencing a downturn may experience a decline in occupancy, revenues, asking rents, and in the value of the property. These types of granular shocks to local firms or to nearby amenities could simultaneously lead to changes in market rents and mortgage payments. Finally, quality-related renovation and capital improvements may be correlated to both changes in mortgage payments and rents. Demand or supply shocks can affect renovations, generating correlated rents and financing decisions.[2] These dynamics make it difficult to estimate how shifts in financing costs affect rental housing markets using cross-sectional or aggregate data.

Using a linkage in two proprietary property-level rental housing datasets, I overcome these challenges by analyzing the average effect of a refinancing in a quasi-experimental empirical setting. In a difference-in-differences strategy, I examine the expiration of prepayment lock-outs that force landlords to refinance into a new loan, comparing them to landlords in the middle of their lock-out period in a stacked comparison group. Heterogeneity analyses help identify two reasons for landlords' changing their behavior, leverage and liquidity constraints, and the many margins along which landlords can adjust, including increasing (or decreasing) tenant rents or changing their leasing behavior. Finally, the paper shows the aggregate economic consequences of these financing cost shocks, measured with city-level rent indices.

The main empirical strategy uses variation in financing costs across refinance mortgages for the same property. This strategy exploits contract characteristics called prepayment lock-out periods, which prohibit refinancing for part of the loan's term. These lock-outs generate exogenous variation in refinance timing for a large segment of the multifamily mortgage market, where the most common mortgage has a ten-year term, fixed rate with balloon payments at loan maturity.[3] I observe the previous and new mortgage for a subsample of properties that originate loans that are sold into commercial mortgage-backed securities (CMBS) in both the prior and the new mortgage. This allows me to construct stacked event study and

[1] See e.g. Glaeser et al. (2013) on capitalization of interest rates into prices for owner-occupied housing; Gete and Reher (2018) on single-family mortgage credit shocks affecting city-level rents through the renting versus home-owning margin.

[2] See e.g. Almeida, Campello, Laranjeira, et al. (2012)) or Reher (2021) on corporate investment response to credit and financing shocks.

[3] Multifamily mortgages are different than the single-family owner-occupied mortgages (30-year, amortizing fixed rate mortgages). Most multifamily mortgages are shorter duration (5, 7, 10, or 15 years), and only partially amortize over their loan term. 20 or 30 year amortization schedules are common, so landlords have large 'balloon' payments at the end of their mortgage term (sometimes called 'bullet' repayment if they have interest-only payments for the full loan term).

difference-in-differences regressions to analyze the average change in property-level outcomes as landlords prepay their old mortgage and originate a new refinance mortgage. In supplemental analyses, I consider a group of properties that are sold instead of refinanced, where I observe both the prior mortgage performance, and the new mortgage originated by a new landlord.

On the average refinance, debt service payments fall by 13%, while landlords raise revenues over the same time period by 3%. Drawing on the richness of the linked datasets, I verify that this seemingly contradictory result is not due to the timing of renovations, or due to selection in properties that are refinanced versus sold to new landlords. The timing of the changes in occupancy, revenues, and rents begin 1-2 years before a refinance, but continue after the year of a new mortgage origination. This pattern exactly matches potential frictions in capital markets: lenders and appraisers generally only have access to the 2 or 3 most recent annual financial statements and a rent roll from within 3 months of the refinance closing date. I investigate two other potential channels that could explain why landlords would have an incentive to increase revenues at refinance: leverage on the existing mortgage, and exposure to increasing mortgage rates on the new loan. When they are at risk of being underwater, landlords are more likely to increase revenues, which may raise the appraised property value. Landlords exposed to rising mortgage rates also increase revenues more, consistent with some 'pass-through' of higher mortgage payments. Neither of these channels fully explain the change in financial outcomes for the average refinance, though the rise in occupancy appears to be driven primarily by more-levered landlords increasing their property's occupied units. To complement this analysis I show some 'extensive margin' results on how leverage and rate exposure affect landlords' decisions on probability of renovation, property sale, and distress on the existing loan.

A key result of these analyses is that as financing costs fall, landlords raise revenues and asking rents rather than lower them. What can account for such a pattern? I clarify the channels by which landlords respond to financing cost shocks in a stylized model. Landlords have market power and decide whether to pay discrete adjustment costs, which may represent information or search-related costs.[4] Paying discrete information costs allows landlords to re-optimize their pricing and leasing effort, increasing their net income.[5] In the model, changes in financing costs are salient because (a) an increase in mortgage payments can raise the risk of negative cash flows or mortgage default (liquidity constraints); and (b) around a refinance properties are marked to market based on their current net income, meaning this is the only time landlords can cash-out their equity in the property (frictions in equity extraction or capital markets).

I investigate the information cost channel by showing empirically that landlords correct rent mispricing and update leasing effort in response to each of the financing cost shocks. I create a measure of mispricing and leasing effort for each property in the years before the financing cost shocks. The measures are based on the difference in the property's own asking rent per square foot and vacancy rate compared to every other property within a narrow geographic submarket. Relative to the control group, landlords fix mispricing 60% faster than normal and update leasing 30% faster in the year before and during a change in the financing structure of the property.

Finally, I estimate the aggregate effects of changes in financing costs on rental prices through the "rental financing channel." I develop a measure of city-level financing cost shocks using the interaction between the share of multifamily mortgages prepaying or maturing and the exposure of existing mortgages to changes in

[4]Consistent with this market power channel, Watson and Ziv (2021) argue that vertical differentiation generates significant market power for landlords. Their estimates of negative own-price elasticities of demand are between -2 and -6.

[5]The presence of information costs is consistent with the discussion of distorted beliefs in Giacoletti and Parsons (2022). It matches the real-world presence of large property and revenue management industries focused on information and consulting for landlords. These information frictions and price-setting behaviors are discussed at greater length in Park (2023) and Calder-Wang and Kim (2023).

mortgage rates. The main regression shows the effect of these financing cost shocks on a hedonic city-level rental price index based on Census data on rents and housing characteristics.

I find that over the past 20 years, multifamily mortgage originations and rate exposure has measurably influenced rental prices. The financing cost shocks are positively related to rent growth. Cities more exposed to lower mortgage rates have lower rent growth, and cities exposed to higher mortgage rates experience higher rent growth all else equal. I find that in cities with 5 percent of mortgages prepaying or maturing, one percentage point higher rate exposure is related to 0.3 percent higher rent growth (and vice versa). I conclude that financing costs have aggregate consequences for renters beyond their role in affecting employment or homeownership decisions.

1.1 Contribution

In interpreting why financing frictions and costs have real effects, I connect the rental housing market to the empirical finance literature on the real effects of financing costs (Modigliani and Miller 1958; Myers 1977; Whited 1992). Firms respond to credit or financing cost shocks in other industries by adjusting corporate investment.[6] This paper's analysis of the role of leverage and cash flow constraints studies an entirely new market with extraordinarily detailed data, and pushes forward the literature on the channels by which landlords update their behavior. Giacoletti and Parsons (2022) study pricing in the single-family rental market using cross-sectional rent data. Matsa (2011) also investigates related channels in work on retailer product quality and firms' financial leverage. Notably, I highlight the role of information costs, which can affect both price-setting and leasing behavior. This paper is consistent with evidence of behavioral pricing in other markets, like reference dependence in the single-family housing market.[7] Landlord decision-making connects to pricing policies in other contexts where firms use discrete pricing policies and exhibit the characteristics of rational inattention (Reis 2006; Ball et al. 2005; Matějka 2016; Stevens 2020), and of similar behavioral wage-setting in labor markets (e.g. Dube, Manning, et al. 2020). Park (2023) and Calder-Wang and Kim (2023) study related pricing-oriented contexts in housing markets. I suggest that there is a role for managerial effort, which connects the real estate setting to Jensen and Meckling (2019) theoretical discussion of agency frictions for firms with managerial discretion and choices over financing the firm with debt or equity.

The core empirical results in this paper are the first estimates using within-property variation to identify pass-through of mortgage payments or interest rates in rental housing. Related work has focused on owner-occupied, single-family homeowners changing their borrowing and consumption behavior following changes in mortgage payments through adjustable rate-resets and mortgage refinances (Di Maggio, Kermani, and Palmer 2020; Di Maggio, Kermani, Keys, et al. 2017; Berger et al. 2021), with some evidence on interest-only periods for homeowners in Denmark (Andersen, Campbell, et al. 2020; Bäckman and Khorunzhina 2020; Bäckman, van Santen, et al. 2022). There has only been limited evidence on the effect of monetary policy on rents and renters. Dias and Duarte (2019) (in the U.S.) and Cloyne et al. (2020) (in the U.K.) study the effect of monetary policy shocks on rental inflation or renter spending in impulse response regressions. This paper extends this literature by focusing on the mechanisms, channels, and sources of heterogeneity in how interest rate changes may affect renters or rental housing. There are similar connections to work

[6] See e.g. Almeida, Campello, Laranjeira, et al. 2012; Kahle and Stulz 2013; Danis et al. 2014. There are also related employment effects (Benmelech et al. 2021; Chodorow-Reich 2014), and cash flow effects (Almeida, Campello, and Weisbach 2004; Custodio et al. 2022).

[7] See e.g. Andersen, Badarinza, et al. 2022; Genesove and Mayer 2001; and more widely among investors: Barberis and Xiong 2012.

on: monetary policy's effect on asset prices (e.g. Krishnamurthy and Vissing-Jorgensen 2011); the extent to which monetary policy is context-dependent (state-dependent in Eichenbaum et al. 2022 or path-dependent in Berger et al. 2021); and how the mortgage market channel of monetary policy affects inequality (Coibion et al. 2017) and may have differential effects by race and income (Gerardi et al. 2021; Cloyne et al. 2020; Kiefer et al. 2021; DeFusco and Mondragon 2020).

Complementing the growing interest in market power in labor and product markets, this paper contributes new estimates of cost-related pass-through to rents, occupancy, and revenues—an essential ingredient to analyzing incidence. This fits into research on landlord behavior and competition including Watson and Ziv (2021) who quantify mark-ups in New York City, and research empirically quantifying the connection between user costs and rents (e.g. Goeyvaerts and Buyst 2019; Garner and R. Verbrugge 2009) or the incidence of taxes on residential or commercial real estate (Goodman 2006; Rolheiser 2019). Given my focus on the cost of debt financing, an important segment of the prior literature has considered how financing costs affect rental housing, tenants' tenure choice, and landlords' decisions in other contexts like eviction, renovation, or maintenance (Seltzer 2021; Ambrose, An, et al. 2021; Reher 2021; Giacoletti and Parsons 2022; Greenwald and Guren 2021; McCollum and Milcheva 2020). This paper represents an advance in data construction by linking asking rents and net income at the property-level for a large set of apartments, connecting to research on the measurement of rental prices and quality across space and time.[8] The results here indicate that policymakers should use caution when interpreting price series from listings or from net income-based approaches, because in some cases (like responding to cash flow shocks) asking rents and property-level revenues can move in opposite directions.

Section 2 introduces the main datasets and presents stylized facts. Section 3 introduces the refinance empirical analysis and results. Section 4 discusses a conceptual framework for thinking about landlords' decisions around financing cost changes. Section 5 presents results consistent with these channels and mechanisms on frictions leading to landlords' updating pricing and leasing behavior. Section 6 examines on aggregate effects of financing cost shocks. Section 7 discusses implications and concludes.

2 Data & Stylized Facts

2.1 Main Data Sources

This paper features a novel linkage of data from two proprietary data providers, which is necessary to study the effect of changes in financing costs on rental housing. First, to study the property-specific effects of shifts in financing costs, I need to link data on the financial outcomes of landlords' individual properties and details about the mortgages connected to those properties over time. I use the universe of securitized multifamily mortgages from Trepp to construct this data, which has national coverage of 64 thousand unique properties from the late 1990s to 2020. Second, to study changes in landlord behavior, I need property-level detail about rents that landlords are posting on the market, concessions landlords offer to new tenants, detailed vacancy or occupancy rates, and quality-related characteristics about properties (e.g. amenities available to tenants). I use a dataset from REIS by Moody's Analytics on the universe of market-rate apartment buildings. This is proprietary data based on surveys of every property owner and manager, which covers 37

[8] Several papers measure rents using different approaches, including repeat-rents for the same units (Ambrose, Coulson, et al. 2015) and within-property variation in revenues or net incomes (Ambrose, Coulson, et al. 2022); and more recently, applies those rent measures to study other questions, like labor demand shocks (Howard and Liebersohn 2021) and market power (Watson and Ziv 2021).

thousand unique properties in 48 CBSAs for the fourth quarter of each year from 2005-2019. The average property in Trepp and REIS is 190-200 apartment units. I briefly describe the datasets and the construction of estimation samples in this section. Additional detail is available in Online Appendix A.

To study securitized multifamily mortgages, I construct an annual panel of mortgage characteristics, monthly payments, and outcomes at the property-level going back to the late 1990s. The raw datasets from Trepp contain information about borrowers, multifamily properties, & mortgage characteristics.[9] I observe property values at securitization.[10] Mortgage data includes loan characteristics and eventual mortgage disposition for loans that have matured or prepaid as of 2020.

Landlords who borrow multifamily mortgages report their financial statements to servicers, enabling me to construct a property-by-year panel of financial outcomes and to link property outcomes across mortgages. This panel includes financial outcomes on annual revenue, operating expenses, total debt service payments, and net cash flows.[11] The original Trepp databases are not structured to track individual properties across mortgages. I use the address and location information to build a panel including a subset of properties' financial outcomes across mortgages. This is a necessary step to study the effect of a refinance. I can observe for most loans post-2007 how the initial mortgage is disposed (matures, prepays in open, prepays with penalties, or REO/foreclosure), and the purpose of the newly originated mortgage (refinance, recapitalization, acquisition, construction, etc.).[12]

This paper is among the first to link financial outcomes & market asking rents with the ability to look at these outcomes across mortgages for the same property. I merge address-level data from Trepp with data from REIS (by Moody's Analytics) to study asking rents, occupancy, and concessions for market-rate landlords. Information is collected from surveys of landlords (owners and managers), and the sample used in this analysis is from Q4 of each year. The address merge between Trepp and REIS includes 16 thousand properties. Only 9 thousand of those properties have panel information on financial outcomes and market rents for overlapping years. This provides a range of information about how landlords respond to changes in the cost of financing rental housing, and allows me to verify how changes in average revenue per unit are related to changes in market rents and free rent concessions for new leases (e.g. asking rents and effective rents). To the best of my knowledge this paper is the first to create a property-level panel simultaneously observing market rents, financing, and financial outcomes.

As a brief description of the property financial data, Figure 1a shows the average values of revenue, operating expenses, and debt service per unit (divided by 12 to approximate the amount per month) for all observations in the Trepp database. The average property in 2020 earned $1,290 in monthly revenue per unit, while spending $620 in operating expenses (47% of revenue) and $400 in debt service payments (31% of revenue).[13] On average, securitized large apartment buildings' have 22% operating profit margins before

[9]The panel of mortgage outcomes is at the year-level to match to the property-level financial statement data, which reports full-year financial outcomes. Multifamily mortgages can include multiple properties as collateral. In the relatively infrequent cases of multiple properties backing the same loan, I cluster standard errors at the loan level in regressions since this is the source of financing cost variation. Trepp's existing unique loan identifiers allow me to easily link mortgages to property identifiers within each loan term (but the Trepp-provided identifiers do not link across loans or refinances).

[10]Most Appendix B discusses several institutional details about appraisal and valuation in multifamily real estate, focusing on publicly available GSE guidelines.

[11]Borrowers also report occupancy rates to servicers, though they report occupancy rates less frequently, and without consistent periodicity (e.g. sometimes reporting in Q1, and other times reporting in Q3).

[12]For the across-mortgage analysis, I define sequential mortgages as cases where one mortgage prepays or matures, and the next mortgage has a recorded origination date within the 3 months around the prior mortgage's prepayment or maturity date.

[13]I benchmark this average amount relative to Census data. In Census' American Community Survey, the average gross rent in 2019 was $1,164, so the average revenue per unit from Trepp securitized properties may represent disproportionately higher quality buildings, neighborhoods and cities than the national average. This is consistent with Black et al. (2020) observation that securitization disproportionately funds safer collateral in commercial real estate. The per unit revenue figure includes

capital expenditures (or $280 in net cash flow after mortgage payments).

I show the size of the sample of properties in securitized mortgages in Figure 1b, and note that the size and composition of securitized mortgage origination changed over time. New originations grow from 2,500 per year in the late 1990s to 15,000 per year in the late 2010s. Growth in securitization accelerated as the GSEs expanded their role in the multifamily market during and after the Great Recession.[14] According to the National Multifamily Housing Council, there are 21 million apartment rental units in the U.S., making up around 1 in 7 housing units in the country. Based on back-of-the-envelope calculations, about half of those apartment units (13 million units) are covered by the Trepp dataset at some point.[15]

To study the aggregate effects of financing cost shocks, I construct a city-level rent index using Census public-use micro-data (American Community Survey from IPUMS Ruggles et al. 2022). I use core-based statistical areas as a measure of city housing markets. I develop a hedonic rent index by recovering year-by-CBSA coefficients from a regression of log gross rents on several housing characteristics (number of bedrooms, type of structure, etc.) and a year-by-CBSA fixed effect.[16]

Appendix A discusses each of these datasets in greater length with additional details about merging and validating the proprietary data. I use several other supplementary public data sources including house price indices from the Federal Housing Finance Agency (Bogin et al. 2019) to proxy for changes in current LTVs, and inflation and labor market data from the Bureau of Labor Statistics to adjust for price changes and control for labor market conditions.

2.2 Stylized Facts

I present two new stylized facts about multifamily rental housing and financing costs. First, the debt service share of revenue has declined over the past 20 years. Second, operating margins for the average landlord have risen since 2003.

Figure 2 shows that between 2003 and 2020 the debt service share of revenue fell from 37% to 30% (a 19% decline; solid line in maroon x's). These figures use within-property variation to account for changes in sample composition. To do this, I regress operating margin and debt share on year fixed effects and property-specific fixed effects, and plot the constant plus the year fixed effect coefficients.

Over the same period, landlords' operating margins have risen (dashed line in green diamonds). Operating margins grew from 16% to 22% (a 37% increase). I benchmark to 2003 because it is just after the 2001 recession and several years before the Great Recession.[17] Operating margins are calculated as revenue minus operating expenses and debt service payments divided by revenues. This rise in operating margins is significant because it indicates that the share of rental income that landlords earn as profits has increased. The timing of the rise in operating margins suggests that declining debt service payments played an important role.

Interpreting these time series relationships is fraught because of the sources of endogeneity discussed in the introduction. Those issues include endogeneity due to (1) the relationship between interest rates and the

parking and other amenity fees. It does not represent exact average rents since there is no adjustment for vacancy losses or credit losses.

[14] I include Ginnie Mae in Figure 1b for completeness, but note that (a) very few FHA loans report complete mortgage characteristics (LTV and DSCR at securitization); (b) almost none report ongoing property-level financials; and (c) Ginnie Mae multifamily loans are for affordable and subsidized apartments, so they cannot be matched to the market-rate multifamily rent data from REIS. Thus, Ginnie Mae properties are excluded from the main analyses.

[15] The REIS dataset covers about 40-50% of total rental units in the 48 largest cities.

[16] The methodology and procedure for this rent index is similar to that used by Albouy et al. (2016) to study changes in housing demand and cost of living.

[17] There was a decline in expenses as a share of revenue around the 2001 recession—I do not investigate that in this paper.

property value, (2) changes in property quality and operations around financing cost shifts, and (3) granular geographic changes in neighborhood amenities and labor markets that affect both rents and financing costs.[18] These facts help motivate a causal identification strategy to study how within-property changes in landlords' financing costs affect tenants.

3 Effect of Financing Costs at Refinance

When refinancing into a new mortgage, mortgage payments change and landlords change their equity position in the property (either cashing-out or injecting equity, in the case of cash-in refinance). This section proceeds in several parts: (1) discussing the empirical strategy and setting to study average effects of a refinance; (2) showing descriptive parallel trends then event study and difference-in-difference results for refinance and control group properties; (3) exploring heterogeneity in financing cost shocks focusing on property-level mortgage rate exposure & loan-to-value ratios; (4) generalizing these results to include all refinances and sales observed in the securitized mortgage data; and (5) showing the relationship between financing cost changes and meaningful property-specific decisions including probability of renovation, sale, and distress (including default, foreclosure, or impaired sale).

3.1 Empirical Framework for Refinances

This section introduces an empirical strategy to analyze changes in property-level outcomes around the time a landlord refinances into a new mortgage. Because normally the timing and terms of refinancing are endogenous, I exploit variation in mortgage contract terms, called prepayment lock-out periods, to provide plausibly exogenous variation in refinance timing. Prepayment lock-outs prevent or make it prohibitively costly to refinance during the lock-out period. Lock-out periods are very common, with 60% of loans in 2019-2020 including some type of lock-out, as shown in Figure 3.[19] The group of treated loans in the main analysis have lock-out periods lasting up until the final year of the mortgage term. Generally, these loans have 10-year terms, and the most common prepayment lock periods are for 108 or 114 months. This means that landlords cannot refinance until the final 12 or 6 months of the 120 month loan term. In the primary results, I focus on the dynamics of property-level financial outcomes around refinance for properties whose ownership and quality do not meaningfully change, meaning I exclude property sales or renovations. In subsequent subsections, I show results including properties that were sold and renovated, and the relationship between financing costs shocks and the probability of selling or renovating.

The treated properties that undergo a refinance are compared using event study and difference-in-difference regressions with a control group of properties that do not refinance during the same event window. A cohort of treated properties, indexed by c, is defined as a group of treated loans with the same quarter of prior origination and quarter of new refinance origination, and with the same seven-year period of calendar years around the origination year of their new refinance loan (called the 'event window' going forward). Each cohort of properties in the control group are originated five or six years after the treated group's original loans, so control group properties are in the middle of their mortgage term during the event window (when

[18] Appendix A2a shows the binned scatter plots of the cross-sectional and panel relationship between property-level asking rents and debt service payments.

[19] Other common mortgage characteristics also make early prepayment very costly. These include include prepayment penalties or premiums, defeasance (where a prepaid mortgage is swapped with a comparable asset like a Treasury security), and yield maintenance (which is similar to a prepayment penalty, but structured as a function of the present value of remaining interest payments).

I compare them to the treated group). The control group properties are constructed into stacked comparison groups in calendar time to absorb common economic shocks that would affect property-level revenues, expenses, and occupancy. This construction allows me to use a balanced panel for each cohort of the control group outcomes over the same calendar years as each cohort of the treated group properties. The calendar years are re-centered around the origination year, which is defined in event time as $d = 0$.[20] I index property fixed effects by cohort, $\alpha_{p(c)}$.[21] For the stacked event study regression, cohort-specific event time by calendar year fixed effects are included so that treated properties are compared to control group properties within each time period and cohort. This should mitigate potential negative weighting problems with comparing already-treated to later-treated units in some difference-in-difference settings.

The goal of this empirical strategy is to use balanced panels and clean control groups. The stacking approach described above creates a set of clean control groups, but the Trepp data does not always provide a balanced panel of financial outcomes. This is particularly problematic around the year of and year prior to originating a new mortgage. Before landlords begin paying and after they fully pay off a loan, landlords generally do not report financial statements to their servicer. This means about half of landlords do not report their property-level financial outcomes for the first or last year of their mortgage, which are $d = -1, 0$ in event time.

To deal with this issue, I use a local projection-style event study to recover average treatment effects of refinancing, following the approach in Dube, Girardi, et al. (2022).

$$\Delta y_{p(c);t+k,t-3} = \alpha_{td(c)} + \sum_{d=-4}^{7} \beta_d \times \mathbb{1}_{p(c)t}(t = d) \times \mathbb{1}_{p(c)}(Orig) + \epsilon_{pt} \tag{1}$$

I regress the change in the outcome variable $\Delta y_{p(c);t+k,t-3}$ relative to three years prior to refinancing on event study indicators around the date of the new mortgage's origination year. The indicator function $\mathbb{1}_{p(c)}(Orig)$ signifies a property is in the treated group which undergoes a refinance at $d = 0$, while $\mathbb{1}_{pt}(t = d)$ takes the value of 1 when the current-year observation occurs d years before or after the prepayment or maturity of the original mortgage. The main coefficients of interest are the event coefficients β_d, where event time $d = -3$ is the excluded period. The main event study results are measured relative to three years prior to a refinance.

In the main difference-in-difference regressions, only balanced panel observations are included. I restrict to the periods before and after refinancing: $d = -4, -3$ and $d = 1, 2$. This simple difference-in-differences on stacked comparison groups allows straightforward interpretation of the event study results.

$$ln(y_{p(c)t}) = \alpha_{p(c)} + \alpha_{td(c)} + \beta_{DD} \times \mathbb{1}_{p(c)t}(d > 0) \times \mathbb{1}_{p(c)}(Orig) + \epsilon_{pt} \tag{2}$$

The coefficient of interest is β_{DD}. It measures the differential change in each outcome for properties originating a new loan, $\mathbb{1}_{p(c)}(Orig)$, in the periods post-refinance, $\mathbb{1}_{p(c)t}(d > 0)$. The exception in panel balance is the occupancy rate reported by landlords to servicers from the Trepp data, which is missing for

[20] I draw balanced comparison groups of properties with ten year loan terms & prepayment lock-outs that are in the middle of their term, stacking comparison cohorts that are balanced in property-level financial outcomes from the second to the eighth year of their loan term (or third to ninth year in some cases).

[21] In this stacking approach, multiple observations of the same control property can contribute to the different control group cohorts (with standard errors clustered by property to account for this stacked control approach). It may present a selection problem to compare properties with loans securitized multiple times to those only securitized once in the Trepp data, but without detailed portfolio mortgage data, it is difficult to evaluate whether this is important—Black et al. (2020) suggest securitized mortgages are safer, but do not provide much context for selection for when the same property enters into or moves out of securitization.

a portion of properties. In robustness checks, I use reported occupancy to REIS, which is balanced in the merged panel to verify and corroborate the results.

3.2 Effect of Refinancing on Landlords' Financial Outcomes

Prepayment lock-out periods provide exogenous variation in the timing of a change in financing costs. While the timing of refinancing is exogenous in the sense that it was determined eight or nine years prior and landlords are unable to change it over the course of those years, this also means that the timing of refinance is anticipated by landlords. If there were no liquidity constraints, unanticipated financing costs, or other financing (or capital market) frictions, then landlords should not change their behavior around a refinance, or at the very least any change they make should probably not be sharp or discontinuous. The exogenous, fixed timing of refinance is useful because while landlords can anticipate the timing, they cannot necessarily anticipate the environment for interest rates or whether local real estate values are increasing or decreasing exactly when they need to refinance.

In the presence of liquidity constraints, we might expect a change in behavior at or just before refinance for landlords who are nearly underwater or who are exposed to an increase in mortgage rates. Because of declining interest rates and rising property values over the past 20 years, those situations have been fairly rare.[22] There is another institutional detail that might lead landlords to change their behavior around a refinance. At refinance, the property is re-appraised and landlords can extract equity. Appraisal guidelines require landlords to provide the current rolls of active leases in the property, and financial statements for the three years leading up to appraisal. This limited information set could have an influence on the property valuation. After studying the average effect of refinancing, I turn to regressions studying within-property change in appraisal values to test this channel. To the extent that landlords can raise revenue, it should be in the two years leading up to a re-appraisal. I examine 4 years prior to refinance to observe anticipatory effects.

In the Figure 4, I graph the main outcome variables from four years prior to a refinance to two years following a refinance for a loan with a prepayment lock during its prior mortgage term. Properties with prepayment locks are lower rent and potentially lower quality, on average. This should not be surprising given that most prepayment lock-out contracts are securitized by Fannie Mae mortgages (which are tilted towards more affordable properties) rather than privately-securitized mortgages (which are more likely to be high quality or market-rate apartments).

The x-axis shows years relative to the year of refinance of the original mortgage—year 0 is the year in which the landlord refinances their mortgage. Debt service payments decline sharply for the refinance group labeled as "Lock→Refi" by $45 per unit, consistent with declining mortgage rates over this time period. The figure shows that average monthly revenue per unit grows over this time period from $960 to $1,080, while revenues are growing in the control group at a slower rate. The graphs provide suggestive evidence of differential revenue growth in the two years leading up to and year of refinancing. There are similar trends in net income and net cash flows.

There is a notable, sharp increase in occupancy rates over the 2 to 3 years prior to a new refinance. Considering the sample restriction to exclude sold and renovated properties, this seems like clear evidence of a sharp change in property-level outcomes that result from landlord behavior. The changes occur in advance of refinancing into a new mortgage. The scale of these effects suggests that the average property which has 200 units increases occupancy by 2%, meaning an additional 4 units are leased.

[22] See Appendix A3 on mortgage rates, and Appendix G14 on the distribution of loan-to-value ratios just before refinance.

In Figure 5, I report the results of the local projection event study regressions. Debt service payments decline by 11 percent in the 2 years after an average refinance over this time period (Figure 5a). The initial year of refinance is slightly lower at -0.19 likely due in part to the missing data issue discussed above. Figure 5b shows that revenues increase by nearly 4% in the years following a new origination. This increase may begin two years prior to the new origination, though the pre-refinance coefficients are not significantly different from zero. The timing of this increase is consistent with landlords' ability to anticipate the end of their prepayment lock period. The increase is particularly sharp in the year before and year after the new refinance, suggestive of a change in leasing strategy, pricing behavior, or perhaps property quality (unobserved to the econometrician).

Figure 5c shows that operating expenses appear to decline after a refinance, though the change is not statistically significant. This suggests that revenues are not primarily increasing due to an increase in the quality of landlords' operations or 'cost of goods'. There is a sharp increase in occupancy beginning two years prior to refinance (Figure 5d). 2-3% additional units are occupied after the refinance, which is 4 to 6 apartment units in the average property. The limitation with using this financial statement data is that I observe the property-specific balance sheet, but most property managers are paid as a fixed share of revenues (not on an hourly or per-employee basis). This means that 'landlord' effort or costs on the margin may not be captured by the property-level financial statements. This property manager compensation issue is another potential agency friction related to monitoring or information frictions.

Corresponding to the increase in occupancy, net incomes increase in the two years prior to refinance, resulting in net incomes that are 10% higher two years after refinance (Figure 5e). Net cash flows increase by the equivalent of 120 log points, though this is slightly more difficult to interpret because I use the inverse hyperbolic sine transformation to deal with net cash flows that are at or below zero in some periods. In the difference-in-differences specification below, I also report these results in dollar terms.

Table 1 shows the stacked difference-in-differences results for landlords with lock-out periods who refinance. Panel A shows the results where outcomes are transformed in natural logs and inverse hyperbolic sines. This is consistent with the event study results—debt service payments decline by 12.5%, revenues rise by 2.9%, and occupancy increases by 2.2%. The increase in net operating income is \$22.5 per unit monthly. An alternative way to interpret the IHS results is to take the effects on net incomes and net cash in dollar levels as percentages of the pre-period treated group averages from the descriptive trends above. Net operating income increases by 4%, and net cash flows increase by 40%.[23] If there were no change in landlord behavior around refinancing, the significant \$37 decline in debt service payments would correspond to a \$37 increase in net cash flows. Instead net cash flows increase by \$60 per unit monthly. For a 200 unit apartment property with average revenues and expenses, this means that the landlords' annual net cash flows increase by \$140 thousand (instead of the \$90 thousand increase due to the change in debt service).

This evidence on refinanced properties suggests that landlords make real changes to their behavior around refinancing. They raise revenues by 3% even though their debt service payments decline by 12%, on average. There is some evidence of landlords' anticipating their refinance event by increasing occupancy and net income in the two years leading up to a refinance. The timing of this effect matches the standard financial statement reporting to appraisers and underwriters.

[23] 4% = (\$22 / \$515) × 100. 40% = (\$60 / \$150) × 100.

3.3 Heterogeneity in Refinancing Effects by Leverage and Rate Exposure

In this section, I examine evidence that the increase in revenues and occupancy is caused by a change in financing costs. I examine differences in the magnitude of effects at refinancing with respect to two sources of financing cost variation. If landlords are cash-flow sensitive, then landlords' revenue change at refinancing should be larger in response to higher mortgage rates. An increase in mortgage rates raises the landlord's cost of debt and the size of their mortgage payment, all else equal. Similarly, if landlords are at risk of being underwater and being forced to 'cash-in' at refinance to pay off their balloon payment, then they should be more aggressive in raising revenue. Increasing revenue in anticipation of refinance may help raise the appraised value of the property. Because lenders price property-level credit risk, raising the appraisal value could also lower the cost of debt by lowering the landlord's LTV.

To test for heterogeneity, I interact the two measures of financing cost variation (mortgage rate exposure and mark-to-market leverage) with the difference-in-differences treatment variable in Equation 2. In the first set of results, the interaction effects are linear. In a second set of results, I relax the assumption of linear, symmetric effects for higher versus lower financing costs in the rate exposure and LTV variables by using binary variables for high LTV (greater than 80%) and exposure to higher mortgage rates (mortgage rates increased since their prior origination).

I use two sources of financing cost variation: mortgage rate exposure and mark-to-market leverage before refinance. The first variable is the property-level exposure to changes in mortgage rates since the property's prior origination date. This variable is defined as the difference between mortgage rates in the quarter the original mortgage was originated and the quarter it is prepaid or matures (i.e. the quarter of the new mortgage refinance origination).[24] The second financing cost variable is the mark-to-market loan-to-value ratio two years prior to the new refinance. The mark-to-market LTV is constructed: (1) using the remaining loan balance at the beginning of the year; and (2) by merging a zip code by year-level FHFA house price index (constructed by FHFA based on the universe of single-family home sales). I project the appraised value of the property from the original mortgage's origination year to two years before the year of the new mortgage refinance. Property-level differences in LTV can come from at least two sources. First, landlords' existing loans may have differential rates of amortization (e.g. through interest-only periods or different original maturity or amortization term). Second, the location of the property may experience differential changes in value. The use of the FHFA house price index is useful because it provides a meaningful proxy for the value of the location without using any information from the apartment buildings in this data.

To explore this source of variation, I show the relationship between revenue growth and asking rent growth with mark-to-market LTV before the refinancing or sale of properties in my sample. Figure 7 shows these relationships. Revenues growth increases with leverage around a capital event. In contrast, asking rents increase with leverage only in the case of refinances. Sales of highly leveraged properties have relatively lower asking rent growth, though still higher than the comparison group over the same time period. It could be the case that sales are selected into properties that are ex ante underpriced regardless of the previous landlords equity position. In the next paragraph, I discuss the analogous regression results and additionally control for property-level mortgage rate exposure at the time of the capital event.

The results are reported in Table 2 for the regressions with the outcomes log and inverse hyperbolic sine transformed.[25] Panel A shows results using the specification for the difference-in-differences above. The only

[24] I create a multifamily mortgage rate index, shown in Appendix Figure A3. I construct rate exposure for the control group based on the stacked comparison approach, where each cohort of the control group is drawn by assigning same prior origination year and new origination year corresponding to each cohort of treated loans.

[25] The effects in terms of dollars and levels are reported in Appendix Table C1.

difference in the sample from Table 1 is that properties in this heterogeneity analysis are matched to zip codes with FHFA house price indices have coverage. The results are quantitatively similar to Table 1—debt service payments decline by 13% and revenues rise by 3%.

The first column of Panel B in Table 2 shows the effect of mortgage rate exposure and mark-to-market LTV on the change in debt service payments. One percentage point higher mortgage rates (100 basis points) cause 10.1% larger debt service payments. Ten percentage points higher existing LTV (e.g. moving from 70 to 80% LTV) results in 3.4% lower debt service payments on the refinanced mortgage. This indicates that higher LTV landlords deleverage at refinance. The debt service payment outcome should include all-in debt service payments. This implies that the financing cost measures can be endogenously related to landlords' borrowing decisions—for example, landlords' exposed to lower rates may choose longer duration loans, and those with higher leverage may choose smaller loan balances. The fact that each variable significantly affects debt service payments suggests that these measures of financing costs are meaningful proxies for the property-level cost of debt.

The second column shows that the effect of refinancing is heterogeneous with respect to mortgage rate exposure—one percentage point higher mortgage rates results in landlords raising revenues by 2.2% and 10 percentage points higher LTV results in landlords raising revenues by another 0.57%. There is little evidence that changes in operating expenses are strongly related to changes in financing costs. Occupancy rates appear to be strongly related to leverage. Properties with higher LTV raise occupancy at refinance. These results are evidence that financing costs are correlated with landlords' behavior and suggestive of a strategic response at refinancing.

Are landlords' solely changing their behavior at refinance because of discontinuous changes in financing costs (or liquidity constraints)? I test this in Panel C by relaxing the linearity assumption on the rate exposure and LTV interactions. The difference-in-difference coefficient is interacted with an indicator variable for properties exposed to an increase in mortgage rates (about 10% of properties in this sample period), and an indicator variable for having an LTV greater than 80% in the years prior to refinance (15% of the sample). The cut-off for LTV is potentially meaningful given that securitized multifamily mortgages are rarely originated with LTVs above 80% and the average LTV at origination is between 65 and 75%, depending on the market segment (Fannie Mae, Freddie Mac, or private and conduit). Landlords exposed to higher mortgage rates experience an increase in debt service payments of 45% relative to the average property exposed to lower rates. Landlords with high leverage refinance into loans with 10% lower mortgage payments, suggesting that they endogenously respond to being underwater or having to cash-in by reducing the size of the loan balance in their new refinance mortgage.

Properties exposed to both higher mortgage rates and higher leverage at refinance raise revenues. However, properties with declining rates and lower LTVs also increase revenues, on average. The revenue increase is 7.4% higher for properties exposed to higher mortgage rates and 2.7% for properties with higher leverage, though only the effect for properties with high leverage is statistically significantly different from zero at the 95 percent confidence level (Column 2, Panel C). The group of properties with lower leverage and declining mortgage rates still significantly increase revenues (2.2%) and occupancy (2.0%).

This last set results in Table 2 are particularly informative because they suggest that discrete liquidity constraints are not the sole reason that landlords change their behavior at refinance. Even marginal changes in cash flow liquidity or leverage positions appear to causally affect landlords decisions.

3.4 Effect of Originating a New Mortgage, Comparing Refinances, Sales, and Including Renovations

Next, I analyze all matched refinance and sold properties from the Trepp securitization data, including properties without prepayment lock periods. This analysis is useful for two reasons. First, it speaks to external validity, confirming that the results for locked refinances are likely not due to selection in what types of landlords' choose prepayment locks. Second, this provides a larger sample of properties to study, increasing the treated group from 425 to 858.

Table 3 shows these results controlling for renovations and separately estimating the average effect of originating a new mortgage through refinance versus sale. The average renovation results in higher net income, but controlling for these renovations does not change the main effect of refinancing.[26] While renovations may be relevant, the main refinancing effect is distinct. This setting seems to be quite different from evidence on corporate investment among firms (Almeida, Campello, Laranjeira, et al. 2012), and from owner-occupied refinancing, which can be used for debt repayment (Di Maggio, Kermani, Keys, et al. 2017), home improvement or other spending (see e.g. Melzer 2017 or Greenspan and Kennedy 2008).

The indicator for 'Sale' allows for a separate average effect on properties whose new mortgage is classified as an acquisition or sold property. It is striking that the effects on debt service, revenues, occupancy, and cash flows are so similar to the main refinance effect when there is a change in ownership. These results suggest that the main lock-out refinancing coefficients in the previous section are not driven by selection of low quality landlords into prepayment lock-out mortgages. Instead, there appears to be behavioral change, or a change in strategy that leads to similar growth in net income even when the property changes ownership. This common effect on refinances and sales helps motivate my discussion in the next section of mechanisms and frictions, like information costs and belief updating that lead landlords to update pricing and leasing strategy.[27]

To complement the results on financial outcomes in Trepp, I examine the average effects of refinancing on asking rents and free rent concessions using the subsample of properties merged between Trepp and REIS. These results are based on a balanced panel of private sector data (unlike the CMBS data from Trepp, which has some missing observations in period $t = -1, 0$. The descriptive trends are shown in C8. I use the local projection event study approach and report the average financial outcomes for the same merged Trepp-REIS subsample in Appendix Figure C7. Asking rents dip in the year prior to refinancing or sale, then increase by 2.5 percent in the next two years. Free rent concessions (measured as number of months of free rent) rise by about 0.1 months of free rent in the year following a refinance or sale, but the change is not statistically significant after two years. The fact that asking rents and occupancy rates both increase suggests that asking rents (or posted rents online) might not describe the dynamics of rents paid by existing tenants at renewal. Asking rents and renewal rents could move in different directions or in the same direction at very different rates. This suggests that the loss-to-lease ratio (i.e. the gap between asking rent and renewal rent on the same unit) is endogenous to landlords' strategy and, in the case of this paper, to the landlords' financing costs.

Contrasting with the focus on corporate investment in studying firm-level financial constraints (e.g. in

[26]The fact that the average refinance results are very similar controlling for sales and renovations should be reassuring. We may still be interested in how financing cost shifts affect these other margins of landlord behavior. Notably, financing cost shocks could affect the probability of renovation, sale, or default. In Section 3.5, I show that financing cost shocks do act through those channels, but I find no indication that those channels explain the main refinancing effect documented in Section 3.

[27]I include heterogeneity results looking at rate exposure and LTVs for all refinances and sales in the Online Appendix. Those results are qualitatively and quantitatively similar to the lock-out refinance sample.

Almeida, Campello, Laranjeira, et al. 2012), landlords are able to increase revenues with little or no evidence of substantial changes in product quality, investment, or cost of sales (e.g. the explanation for effects on employment in Benmelech et al. 2021). The change in asking rents and occupancy suggests that there is an important frictions, like an information or belief updating channel, where landlords have some scope to re-optimize their pricing and leasing. The existence of this channel is consistent with the use of stale information or reference dependence in other housing market contexts (e.g. Giacoletti and Parsons 2022 or Genesove and Mayer 2001). I also note that in many cases 'landlords' is not specific enough for describing decision-makers in this setting. In the multifamily sector, the owners of the property who originate the mortgage may be different from the day-to-day managers of the property who make operating decisions around leasing and pricing. This is a challenging setting because about 80% of property management companies are compensated with a contract based on a fixed share of annual revenue. It could be that the 'economic cost of sales' is increasing when managers exert effort on leasing, but those costs are borne by the manager in an accounting sense—the cost of leasing, searching, or negotiating may not show up on the property-level financial statement. In that case, we should interpret rental housing markets as having information frictions and agency frictions that require endogenous monitoring activity on behalf of owners or investors. Debt may be particularly useful for investors or absent owners as a focal point for monitoring and evaluating on-the-ground managers. Debt as a way to focus, or even to outsource, monitoring activity connects these results to the old problem from Jensen and Meckling 2019 of the role of managerial behavior and the trade-offs in the firm financing decision between equity and debt.

3.5 Relationship Between Financing Costs & Renovation, Acquisition, and Default

I consider now how outcomes for properties exposed to higher mortgage rates differ based on three decisions by the landlord: whether to sell the property, whether to renovate the property, and whether to default (including any instances where the lender or servicer sells or works out the loan at a loss). The linear probability of these outcomes are estimated with a regression specification including year fixed effects, and subsequently adding metropolitan area fixed effects and year-by-metro fixed effects. This specification estimates effects of shifts in financing costs within year, or within city and year. Importantly, this within-year and within-city variation isolates the effect of financing costs at the loan level on the probability of each outcome, not necessarily the effects of aggregate shifts in rates or prices on overall renovations or multifamily acquisitions. The main outcome is an indicator variable for the presence of an acquisition, renovation, or loss within the main estimation sample. While mortgage origination volume falls overall in response to higher mortgage rates, the results below speak more to the composition of new mortgages originations.

Over this time period, 30% of mortgage originations are property sales or acquisitions, and 24% of properties undergo a renovation in the three years around a new origination. Only 5% of mortgages default, are disposed at a loss by the servicer, or have an impaired loan payoff.

In Table 4 Panel A, I find that (1) higher ex ante LTVs are negative correlated with the probability of renovation and (2) higher property-specific rate exposure is positively correlated with the probability of renovating the property. One caveat is that I measure rate exposure based on the quarter of prior origination and quarter the prior mortgage is prepaid or matures, but I allow the renovation outcome to include properties that are renovated one or two years prior to the origination of the new mortgage. This is particularly interesting because the usual logic of capital investment is that interest rates are an important part of the price of investing capital on the margin, so investment should rise when rates are lower.

In the multifamily rental market, it appears that landlords make capital investments when their properties are facing relatively higher rates at the time of debt turnover. This may be consistent with landlords preferring to use short-term debt to finance capital improvements because the improvements may involve higher returns connected to higher risk. In contrast, they may choose longer duration debt contracts for properties exposed to lower mortgage rates, which makes it unattractive to make capital investments, since landlords cannot extract the equity associated with the renovation for a longer time period. I caveat this discussion by noting again that from 2000-2019 there are few instances where mortgage rates increased significantly over the previous mortgage term, and those few increases were fairly small, usually between 25 and 50 basis points. These results are quantitatively consistent in columns 4-6 which use discrete indicators for properties with LTV above 80% and for whom rates have increased, though the significance of the effect is attenuated after controlling for metro by year fixed effects.

The next panel studies the probability of sale. Panel B suggests that higher LTV properties are more likely to be sold, though the effect is attenuated after adding fixed effects or discretizing the LTV variable. Mortgage rate exposure is positively related to sale probability in the cross-section, but is not strongly related to the probability of sale after controlling for year fixed effects and metro area effects. It is a severe limitation to generalizability that there are very few instances of increases in mortgage rates over the 2007-2019 time period, and those few rate increases were relatively small (under 0.5 ppt). Recent work suggests some non-linearity in single-family owner-occupied mortgage rate lock-in (e.g. Fonseca and Liu 2023), so there may similar non-linearities in the multifamily or commercial mortgage context.

Finally, Panel C of Table 4 shows that ex ante LTV is strongly positively related to the probability of default or loss, though the effect is not significant with metro-by-year fixed effects. There is a weak negative relationship between mortgage rates and losses, though there are relatively few instances of increasing mortgage rates over the past 25 years. Columns 4-6 indicate that the probability of a loss on the loan increases by 6% when the LTV on the property is above 80% in the years just prior to a new origination.

4 Conceptual Framework for Studying Mechanisms and Channels

The goal of this conceptual framework is to provide intuition about how landlords price apartment units, and to explain the empirical results. This framework starts with a discussion of how landlords make decisions on rental pricing and leasing effort, which determines their net operating incomes (revenues net of expenses). In the data, I observe this annually. To model landlord decisions, I assume that landlords are each a single entity and they earn profits in two ways: through net cash flows on annual operations, and through equity distributions when they refinance or sell.[28]

First, I introduce landlords' net income, $\pi(R_{ht}, m_{ht})$, and their pricing decision in the case where they have no debt financing. Landlords solve a profit maximization problem, where they earn revenue which can be calculated by multiplying rent, R_{ht}, by the number of occupied units n_{ht}. The firm cannot change the number of units in the property and occupancy rates are bounded above by the number of units in the building N_h. The number of occupied units is a function of leasing effort m_{ht} and posted rents R_{ht}, so we can write occupancy as $n(R_{ht}, m_{ht})$. Landlords have some cost of operating the building $C(R_{ht}, m_{ht}, N_h)$. If there were no financing costs, landlords would set rents and leasing effort based on $\pi(R_{ht}, m_{ht})$.[29] I have

[28] The legal structure of apartment ownership arrangements can vary. Commonly multiple partners may contribute financial capital to purchase a property, and profits on the property may pay out based on varying contractual investment pay-out structures. Importantly for this conceptual framework, one entity is responsible for operating and managing the property.

[29] For completeness, there is a participation constraint that landlords' income must cover their fixed costs or they will abandon

modeled rental housing as a spot market where rents and occupancy from period t does not carry over to period $t+1$.

$$\max_{R_{ht},m_{ht}} \pi_{ht}(R_{ht}, m_{ht}) = R_h n(R_{ht}, m_{ht}) - C(R_{ht}, m_{ht}, N_h)$$

$$n(R_{ht}, m_{ht}) \leq N_h$$

To study financing costs, I model landlords as financing their apartment properties with debt, paying some per-period mortgage payment with a schedule maturity date $M_{ht}...M_{ht+k}$. The mortgage payments are determined by interest rates, terms, and loan balances from prior periods. Landlords decide whether to refinance their mortgage in each period, a decision represented by ρ_{ht}. The refinance decision is a difficult real options problem, so for this stylized framework, I consider the case where the timing of refinancing is fixed—analogous to mortgages with prepayment locks.[30] Consider the refinance decision as dependent on the discounted value of the change in mortgage payments, the available equity, and the monetary costs of refinancing.[31] If they refinance, landlords extract equity E_{ht}, a function of the value of the property, remaining loan balance and fixed closing and refinancing costs. Assume that the equity available for extraction is based on a loan-to-value ratio which is a fixed portion of the property value. Fixing LTV avoids adding another endogenous variable without changing the main point of the conceptual framework. Finally, this problem is dynamic so that landlords consider their discounted next-period value, a function of mortgage payments and equity entering into next period. This problem can be characterized as

$$\max_{R_{ht},m_{ht},\rho} V_{ht} = \begin{cases} \pi_{ht}(R_{ht}, m_{ht}) - M_{ht} + \beta V_{ht+1}(M_{ht}, E_{ht}) & \text{if } \rho = 0 \\ \pi_{ht}(R_{ht}, m_{ht}) - M^{\rho}_{ht} + E_{ht} + \beta V_{ht+1}(M^{\rho}_{ht}, E^{\rho}_{ht}) & \text{if } \rho = 1 \end{cases}$$

$$n(R_{ht}, m_{ht}) \leq N_h$$

For explication, suppose there are two versions of the world, one where net incomes affect financing costs and one where they do not. In both versions, landlords roll over their debt every period. In the first version, rental pricing and leasing effort are separate from financing costs. Interest rates are assumed to be common for all landlords, so banks do not price in credit risk, and property values are determined by the optimal pricing and leasing based on the spot market, so each landlords' pricing decision has no bearing on their equity extraction.

$$d\pi_R = dR_h n(R_{ht}, m_{ht}) + R_h dn_R - dC_n dn_R = 0$$

In this case, mortgages and financing costs do not enter into rental price-setting on the margin.

In contrast, we can consider a world where landlords roll over debt every period, and rents affect mortgage payments and equity because banks price in credit risk and current rents affect extractable equity.[32]

$$d\pi_R - dM_R + dE_R$$

the property.

[30] Agarwal, Driscoll, et al. (2013) have a closed form solution to an optimal refinancing problem, though commercial mortgages may be even more difficult given the exotic terms available in the mortgage market.

[31] A richer model might provide a larger role for expectations as in Agarwal, Driscoll, et al. (2013), and might also examine behavioral refinancing decisions as in Andersen, Campbell, et al. (2020). Because the refinancing decision itself is not the main subject of the paper, I simplify the decision here.

[32] Online Appendix F includes evidence on the effect of within-property changes in asking rents and revenues on property values, LTVs, and mortgage rates.

This world should feature rental prices where, depending on the set-up, mortgage costs could fully pass through to rental prices. This pass-through may not be one-to-one given that any financing cost change depends on the net effect of a financing cost change on mortgage payments and equity extraction. Even in this world, where rents have a marginal effect on financing costs, it is simple to write down a model where financing costs should not affect pricing behavior—for example, if rents enter into mortgages and equity only through their relationship with current net incomes, then $d\pi_R - dM_\pi d\pi_R + dE_\pi d\pi_R = 0 \equiv d\pi_R = 0$. In words, if rents only affect financing costs through their effect on net operating incomes, then optimal rental prices should not differ from a version of the world with no debt financing.

The first test of this paper is whether these simple models of rental pricing are useful approximations of how financing cost shocks affect rental outcomes. The main regression results provide compelling evidence that shocks to mortgage financing affect landlords' net income, but less so the mechanisms and channels.

4.1 Information Frictions and Pricing Policies

In this section, I explore one mechanism by which landlords change their behavior around a discrete change in their financing costs. The above section sketches out a stylized model where landlords have monopolistically competitive pricing power—they know the elasticity of occupancy with respect to rental prices, $\frac{dn}{dR}$. Here, I consider an addition to the model where landlords only observe a signal of this elasticity, and it is costly to update their information about the price elasticity of demand they face in any period.

Suppose there exists a true price elasticity of demand ϕ_{ht}, which allows landlords to optimally price rents and choose leasing effort $R^*_{ht}, m^*_{ht} = argmax\ V_{ht}(R_{ht}, m_{ht}; \phi_{ht})$. In each period, they receive a noisy signal $\nu_{ht} = \nu_{ht-1} + \iota_{ht}$. The landlord can either optimize based on the noisy signal or pay an information cost δ to observe the true demand responsiveness ϕ_{ht}. This description of landlord signals generates reference dependence, similar to characteristics of cross-sectional rental pricing in Giacoletti and Parsons (2022). There is substantial evidence of reference dependence in the single-family housing market (e.g. Andersen, Badarinza, et al. 2022; Genesove and Mayer 2001; and more widely among investors: Barberis and Xiong 2012).

Landlords will pay information costs to update their pricing & leasing if the value of updating their policies exceeds the cost: $V^*_{ht} - V^\nu_{ht} > \delta$. The existence of these discrete information costs suggests that: (a) there should be sharp changes in rents for individual buildings over time; (b) there should exist rental units that are both over- and under-priced; and (c) in periods where landlords do not pay information costs, they have some scope to increase revenues and net incomes in the next period. Similar firm price-setting behavior is consistent with the existence of discrete pricing policies (Stevens 2020; Matějka 2016), or rational inattention in pricing (Reis 2006; Ball et al. 2005).

4.2 Landlords with Liquidity Constraints

This subsection focuses on the intuition for how information costs and liquidity constraints interact. Consider a distortion in the ability of landlords to smooth profits by borrowing across negative cash flow periods. This friction can represent three real world costs. Borrowing has fixed costs, so going cash flow-negative in one period can result in taking on additional debt which landlords have to pay for when they originate the debt and may have to pay higher interest rates for a subordinate lien or shorter-term debt contract. Negative cash flows could induce mortgage default which could result in monetary penalties or costs that are reputational or otherwise raise their future cost of debt. These may be psychic costs or other behavioral frictions that are commonly studied in owner-occupied mortgage borrowing in the spirit of Andersen, Campbell, et al. (2020). Third, negative cash flows could also result in penalties for asset or property managers because of the structure of compensation for managers (i.e. general partners) or payouts to investors (like limited partners).

I model this friction as a function of the property's current debt coverage ratio $\gamma(\frac{\pi_{ht}+\rho_{ht}E_{ht}}{M_{ht}})$, which is declining in its argument. This function is consistent with liquidity costs that are higher as mortgage payments grow larger than net incomes, $\gamma' < 0$. It enters into the landlord value function

$$\max_{R_{ht},m_{ht},\rho} V_{ht} = \pi_{ht}(R_{ht}, m_{ht}) - M_{ht} - \gamma(\frac{\pi_{ht}(R_{ht}, m_{ht}) + \rho_{ht}E_{ht}}{M_{ht}}) + \rho_{ht}E_{ht} + \beta V_{ht+1}$$

In the case where $\rho_{ht} = 0$ under partial information, landlords will pay the cost of updating their information and pricing strategy if $\pi^*_{ht} - \pi^\nu_{ht} > \delta + (\gamma(\frac{\pi^*_{ht}(R_{ht},m_{ht})}{M_{ht}}) - \gamma(\frac{\pi^\nu_{ht}(R_{ht},m_{ht})}{M_{ht}})$. Because by definition the full information net operating income is larger than the noisy signal income, $\pi^*_{ht} > \pi^\nu_{ht}$, the presence of liquidity constraints will lower the threshold for paying the information costs: $\gamma(\frac{\pi^*_{ht}(R_{ht},m_{ht})}{M_{ht}}) - \gamma(\frac{\pi^\nu_{ht}(R_{ht},m_{ht})}{M_{ht}} < 0$.

My results suggest that these liquidity-related costs may not change discontinuously at one, as Giacoletti and Parsons (2022) assume in a conceptual model of single family rental pricing. Landlords may respond to the risk of hitting their liquidity constraint, or to lenders pricing credit risk based on recent income history. I explore this by showing the effects of mortgage rate exposure and mark-to-market leverage, which, holding fixed the mortgage balance and other terms, increases mortgage payments on a refinanced loan or requires a capital injection or a 'cash-in' at refinance.

4.3 Valuation & Appraisal Frictions

The fact that landlords only realize increases in the valuation of the property at discrete equity or capital events will affect their pricing and leasing behavior under the assumption that there are substantial information costs. This section explores this friction. I mention a related friction before elaborating: lenders may not observe the landlords' full optimization problem, so they rely on imperfect appraisals of property valuation to make lending decisions. In other words, there may be economically meaningful capital market frictions. Under this conceptual model of valuation, an increase in rents or revenues can increase the property's value at appraisal only to the extent that capital markets observe it. Future work might elaborate on the role of expectations or projections, particularly when some parties behave as if they have extrapolative or adaptive expectations (responding more to recent increases in rents, rather than to the full history of rental price changes).

Consider the information cost decision in the time period where landlords are required to refinance, $\rho_{ht} = 1$. The landlord decision now shifts mortgage payments and equity extraction, and locks those changes in through the term of the next loan. To simplify the expression, we can write

$$(\pi^*_{ht} - \pi^\nu_{ht}) + (E^*_{ht} - E^\nu_{ht}) - (M^*_{ht} - M^\nu_{ht}) > \delta + (\gamma(\frac{\pi^*_{ht}(R_{ht}, m_{ht}) + \rho_{ht}E^*_{ht}}{M^*_{ht}}) - \gamma(\frac{\pi^\nu_{ht}(R_{ht}, m_{ht}) + \rho_{ht}E^\nu_{ht}}{M^\nu_{ht}}))$$

The threshold for updating landlords' information and behavior shifts in three ways. The first is unambiguous: an increase in net income should increase the valuation of the property. This allows the landlord to extract more equity today, which raises the probability of paying the information cost. The second term implies that updating the landlords net income should result in a relatively higher mortgage payment if the loan balance is also higher. In a more complex version of the model, we could account for the change in mortgage payments as the present discounted value of the change in mortgage payments and present value of waiting to extract any equity that is left in the property at refinance (continuing to assume the prepayment lock allows us to ignore the option value of refinancing). The third effect is ambiguous in direction. The simultaneous change in net income, equity and mortgage payments affects the liquidity cost function γ. The equity extracted enters into the liquidity cost function to capture the fact that it is easier for landlords to smooth income when they can extract equity. The reverse argument can be made that if landlords have negative equity or are close to being underwater, they may have to pay much higher liquidity-related costs if they need to cash-in.

The earlier empirical results are consistent with these forces. Around refinance, landlords increase their revenue and occupancy when their LTVs are high (especially above 80%) and they risk being underwater or being forced to put cash back into the property (Table 2). Landlords revenue response is also related to their mortgage rate exposure. High costs associated with liquidity or temporary distress that affect pricing strategy is consistent with van Straelen (2021), which studies internal firm capital markets (focusing on home developers and builders). In the next section, I develop an empirical proxy for mispricing ($R^*_{ht} - R^{\nu}_{ht}$) and possibly mis-optimized leasing effort ($m^*_{ht} - m^{\nu}_{ht}$). The measures are based on each building's difference in asking rent and vacancy relative to similar buildings two years before each financing shock.

5 Empirical Evidence on Channels and Mechanisms of Landlords' Behavior

The main empirical results show that landlords increase revenues around financing cost shocks. The conceptual framework provides the basis for testing for discrete updates to pricing and leasing.[33] This section uses the financing cost shocks to show a sharp response in landlords price-setting and leasing behavior: they correct mispricing and update leasing effort around a capital event like a refinance or sale.

5.1 Pricing and Leasing Response to Refinance or Sale

Figure 8 presents the core piece of evidence on mispricing around refinance and sale. Landlords update asking rents in a way that is strongly related to their mispricing before a refinance or sale.[34]

Refinanced and sold properties correct their pricing at approximately twice the rate of the comparison group. On average, properties in the comparison group that are 1 standard deviation overpriced increase asking rents 2.8% less over the next 3 years. The slope of the relationship for properties undergoing a refinance or sale is 5.6% for refinances and 5.9% for sales.

Asking rents rise faster for both refinances and sales, even conditioning on the mispricing factor, consistent with a valuation or appraisal frictions channel. Appraisers could use asking rents levels either to choose comparable properties or calculating potential gross revenues for the income approach to appraisal. I present some evidence for this channel in Appendix F.

Consistent with these pricing corrections leading to higher landlord income, I show the relationship between the mispricing measure and revenue growth over the same time periods. There are two notable insights

[33] To corroborate the existence of price dispersion or possibility of behavioral pricing in rental housing markets, Appendix D presents evidence of rental price and vacancy dispersion and evidence of round-number bunching in asking rents.

[34] Appendix Figure C4 & C5 show histograms of the mispricing and vacancy differential measures for 'treated' properties and control properties.

from this graph. First, the slope of the mispricing-revenue growth relationship is attenuated, suggesting that asking rents do not pass through to revenues one-for-one. The resulting asking rent-to-revenue elasticities are between 0.23 and 0.27 (a 1 percent increase in asking rent leads to a 0.23-0.27 percent increase in revenue). The second observation is that revenues grow across most of the mispricing distribution. Revenue growth is descriptively higher for very overpriced and underpriced properties.

Next, Figure 9 shows the vacancy differential measure, which captures landlord decisions about leasing effort in the two years before a refinance or sale. Figure 9 shows the relationship between the growth in log occupied units and the vacancy differential measure. I plot OLS regressions for each of the three groups (Comparison, Refinance, Sales). The relationships are very similar, but the slopes for refinance and sold properties are steeper (0.36 and 0.42 compared to 0.34). This indicates that landlords more quickly correct poor leasing outcomes around an equity event like refinance or sale. In the second graph, I show revenue growth over these 4 years. In the comparison group, the slope is positive indicating that 1 standard deviation higher vacancy differential leads landlords to increase revenue by 0.8% in the following years. The slope for refinance mortgages is statistically significant and suggests a 4.5% revenue increase from 1 standard deviation higher vacancy differential. This relationship is attenuated for sold properties. This may be due to new landlords making improvements to the property, changing their operations, or being more aggressive about raising asking rents regardless of ex ante vacancy differentials.

The steepness of the slope of the vacancy differential and mispricing measures provides evidence of landlords updating their behavior. So far, these have focused on long differences in rents, occupancy, and revenues. To provide evidence on the timing of landlords behavior updating, I show how the slope of the asking rent-mispricing and occupancy-vacancy differential relationships change in the years around the new mortgage origination. To do this, I take differences in log asking rents and occupied units relative to two years before the new origination (the same year I take the mispricing and vacancy differential measures from). I include event by year by cohort fixed effects, leads and lags to capture the effect of renovations, event study treatment coefficients capturing average changes for the refinanced and sold properties, and the average slope in each period of the mispricing measure for all of the treated and comparison properties. The coefficients of interest, $\beta_d^{treatXmis}$, track the differential change in the slope of the mispricing measure with growth in asking rents (and the vacancy differential measure with growth in occupancy).

$$\begin{aligned}\Delta y_{p(c);t+k,t-2} =&\alpha_{td(c)} + \alpha_r^{renov} X_{p(c)t} \\ &+ \sum_{d=-3}^{6} \beta_d^{treat} \times \mathbb{1}_{p(c)t}(t=d) \times \mathbb{1}_{p(c)}(Orig) \\ &+ \sum_{d=-3}^{6} \beta_d^{mis} \times \mathbb{1}_{p(c)t}(t=d) \times mis_{p(c)t} \\ &+ \sum_{d=-3}^{6} \beta_d^{treatXmis} \times \mathbb{1}_{p(c)t}(t=d) \times \times mis_{p(c)t} \mathbb{1}_{p(c)}(Orig) + \epsilon_{pt} \end{aligned} \tag{5}$$

The results are reported in Figure 10. The top panel shows the mispricing correction for refinance and sale properties relative to the comparison group. In the year a new mortgage is originated, landlords on average correct their pricing more sharply—increasing asking rents an additional 1.8% for 1 standard deviation more underpriced properties (and reducing asking rents on overpriced properties). There is no significant slope difference between the treated properties and control group in the years prior to the new mortgage origination. In the two years following the new origination, the relationship differential attenuates, suggesting that properties in the comparison group slowly 'catch-up' by resetting their rental pricing. This is consistent with slow belief-updating even outside of a large financing shock.

The bottom panel of Figure 10 shows the dynamics of landlords' mis-optimized leasing behavior. Occupancy rates grow for under-leased properties in the year just prior to a refinance or sale. This is consistent with landlords correcting their leasing strategy in anticipation of originating a new mortgage and revaluing the property to cash out their equity. The coefficients imply that 1 standard deviation higher ex ante vacancy leads landlords to raise their occupancy by 1 percent in the year before the new origination. There is little evidence that the coefficient attenuates in the years following the new origination. This suggests that landlords' leasing effort is sticky for at least the 3 years post-refinance. It is possible that over the course of a long loan term, landlords are inattentive to changes in local vacancy rates and rents. The cost shock from a refinance causes landlords to pay attention, re-setting their beliefs, and updating their leasing and pricing strategy during the debt rollover and for at least a few years afterwards. Studying longer-run effects will likely require improved data on rent, landlord finances and mortgages (especially incorporating loans outside of just CMBS).

The combination of these analyses suggests that compared to the control group, landlords fix mispricing 60% faster and update leasing 30% faster in the years around a financing cost shock.

5.2 Do Appraisal Values Reflect Own-Property Growth in Revenues and Asking Rents?

A key channel in the conceptual framework is the rental income to equity value channel. I know of no prior evidence on this relationship. To explain landlord behavior around maturity or prepayment in this section, I study the extent to which own-property changes in observable financials and asking rents affect appraisal values. This is among the first evidence that tests whether asking rents affect valuations independent of changes in revenues or operating expenses. This asking rent channel could be exist because lenders, appraisers, and underwriters use asking rents as a heuristic for market value or as a leading indicator of property income potential. In a world where property valuations were based on the 'highest and best' management of the property, the history of revenues or asking rents may have limited influence on appraisals. In practice, however, appraisers appear to rely heavily on the recent years of financial statements and recent rent rolls provided by landlords.

There are a few plausible channels by which landlords' asking rent (or leasing) decisions could affect appraisal and financing options. For example, Freddie Mac and Fannie Mae underwriting documents point out that often appraisers use the past 3-6 months of rent rolls to evaluate income potential. In the Sales Comparison approach to valuation, the level of asking rents affects how appraisers pick comparable property sales in the area. In the Income Valuation approach, they sum up asking rents over all market-rate units (regardless of whether the tenant is currently paying the market asking rent) to calculate a 'base rent' for the property, then use geographic, standardized assumptions about vacancy loss and rent growth. The use of recent asking rents in either approach could affect the set of comparable properties or affect the base income potential of the property. In fact, the asking rent levels could be important since the GSEs instruct underwriters to evaluate refinancing risk by projecting forward the level of gross potential income using a constant growth rate (which was previously fixed at 2 or 3%, and going forward will be a submarket specific growth rate from REIS—the company whose asking rent data I use here).

I test this asking rent-appraisal value relationship by merging all properties with (a) repeat appraisal observations within-address; (b) property financial outcomes from the original mortgage and the new (refinance or acquisition) mortgage; and (c) asking rents at the beginning of the original and the new mortgage. For this descriptive exercise, I take long differences from the origination fiscal year for the original mortgage to the prepayment or liquidation year for the original mortgage. Below I show the bivariate relationships between change in the natural log of appraisal values with the change in revenue, expenses, debt service coverage ratios (incorporating mortgage payments), and asking rents. Finally, I show the regressions for the bivariate and multivariate ordinary least-squares relationship. After the data merge, I am left with a fairly small sample of properties—including around 627 observations meeting all of the data requirements to be included.

Table 5 shows the results of this OLS regression. Revenue, expenses, and asking rent are each strongly correlated with changes in appraised property values. In addition, asking rent is still strongly correlated with changes in appraisal values after controlling for each of change in revenue, expenses and DSCR, and after controlling for all of them together. This is at least suggestive evidence that asking rents affect appraisers beliefs about property values in a way that is distinct from their evaluations of the property's financials. Whether this distinct channel reflects the actual ongoing value of the property to investors is beyond the scope of this paper. It does appear that this asking rent relationship allows property owners to extract additional equity from their property at the time of a capital event by behaving strategically in regards to their asking rent-setting. The R-squared indicates that variation in growth in revenues, expenses, rents, renovations, and rates explains 81% of the variation in appraisal value growth. 1% higher revenue growth translates to 1.6% higher appraised value, while 1% higher expenses leads to 0.6% lower valuation. Conditional on revenue and expenses, 1% higher asking rent results in 0.2% higher valuation. I find that the entire effect of a renovation on appraised value appears to be absorbed in the growth in revenue and rent growth. The within-property design allows me to control for the property-specific mortgage rate change. The coefficient on rates suggests that 100 basis points higher mortgage rates leads to 1.4% lower appraised value. In Appendix F, I discuss additional results on this within-property long-difference regression, including studying recent asking rent growth, ex post net operating income growth, and changes in mortgage outcomes like property-specific rates, LTV, and loan balance.

6 City-Level Exposure and Rental Prices

6.1 City-Level Empirical Strategy

Studying within-property variation gives us well-identified evidence on individual landlord behavior. Building on that result, this section quantifies the overall importance of the 'rental financing' channel for interest rates by studying city-level rental price indices.

I aggregate exposure to rental financing cost shocks to the city-level. To study this, I use the simple insight that the effect of changes in interest rates (or financing costs) should be moderated through the amount of the rental housing stock that is prepaying or maturing each year (e.g. context-dependence in Berger et al. 2021). Different cities have different exposure to interest rate shocks in the sense that contemporaneous employment growth in the city is not systematically linked to the share of multifamily mortgages that are prepaying or maturing in a given year.[35]

[35] See Table C3. I show that the relationship between share prepaying/maturing and contemporaneous employment and wage growth is zero after controlling for CBSA and time fixed effects.

I develop a financing cost shock variable based on the interaction between the share of prepaying and maturing multifamily mortgages in CBSA c in year t interacted with the interest rate exposure on the stock of multifamily mortgages entering year t. I sum the number of properties and number of units in the Trepp dataset to the CBSA-level, then divide the stock of properties in year $t-1$ by the number of properties whose mortgages prepay or mature in year t—this share prepaying variable is SHP_{ct}. For each property entering year t, I calculate the spread between the current mortgage rate on each property's loan at the beginning of year t and the average mortgage rate on new multifamily origination over that year—this rate exposure variable is REX_{ct}.

As an example of the intuition between these measures, suppose that every existing multifamily mortgage in Kansas City matures in 2012. Here, SHP_{ct} is equal to 1. Now suppose the stock of multifamily mortgages in Kansas City has a current mortgage rate of 5% entering the year 2012, and over the course of the year average mortgage rates on new origination are 4%. In this case, REX_{ct} is equal to -1. Then, by regressing growth in a rental price index on the interaction $SHP_{ct} \times REX_{ct}$, we are estimating the average effect of property owners reducing their financing costs by 1 percentage point (or 100 basis points).

I formalize the regression as follows

$$\Delta r_{c,t-2,t+1} = \alpha_c + \alpha_t + \beta SHP_{ct} \times REX_{ct} + \epsilon_{ct} \tag{6}$$

My main dependent variable of interest is $\Delta r_{c,t-2,t+1}$. This uses a hedonic rental price index, r_{ct}, estimated at the CBSA-level from Census American Community Survey data from 2005-2017. I take differences from year $t-2$ to $t+1$ to study the effect of changes in financing costs in year t on rental price growth within the city (clustering standard errors by CBSA and by year). This choice is informed by the empirical results on changes in rents and revenues around refinancing and acquisition, which suggest that differences in rents at the property level change around the time of prepayment or maturity but those changes do not continue to grow over time—in some cases, they change the year prior to prepayment (so I use $t-2$ as the base year), and the dynamics change little after year $t+1$.

6.2 City-Level Results

To understand the market-level effects of changes in financing costs, I modify the empirical strategies from the property-level results sections. I use an aggregate empirical strategy described by Equation (6), analyzing the response in city-wide rents to financing cost shifts.

To illustrate this empirical relationship visually, I show in Figure 11 the relationship between mortgage rate exposure at the beginning of each year t and rent growth in the three years around that year t. I calculate rate exposure as the units-weighted difference between average market mortgage rates for year t subtracted from actual mortgage rates for active loans in the city at the beginning of each year. The figure separates the relationship between rate exposure and rent growth for cities with high shares of existing properties prepaying or maturing in year t compared with cities with low shares paid off. For this exercise, I choose prepayment probability cutoffs at the 25th (2.8%) and 75th (9.3%) percentile of the city-year prepayment share distribution.

The primary lesson of Figure 11 is that interest rate exposure affects rental price growth in cities with high prepayment, and does not affect rents in cities with low or negligible prepayment shares. This provides evidence of differences in the effect of changes in financing costs on rents based on a coarse measure of differences in prepayment behavior. Next, I formalize these differences in a regression with a linear interaction between shares and rate exposure.

In Table 6, I show the results of regressions based on Equation (6). The results are displayed with the first 3 columns in ordinary least squares regressions, and the final 3 columns including fixed effects for year and CBSA. Columns 1 & 4 display bivariate regressions of rent growth on the share of multifamily mortgages prepaying or maturing. Both columns show a negative relationship between prepayment share and rent growth. This is similar to the property-level results on the interaction between rate exposure and refinancing. The coefficient suggests the average refinance has been into a mortgage with lower financing costs, which has, on average, led to lower average rent growth for tenants.

Columns 3 & 6 of Table 6 show the main results. The specification controls for city and year fixed effects, the share of units renovated, and local employment and income growth.[36] This captures the component of changes in interest rates or credit conditions that could be systematically related to changes in local rental market conditions (the results are similar in Columns 2 and 5). We see that the coefficient estimates are statistically significantly different from zero. The positive interaction coefficient indicates that increasing interest rates has a positive effect rents in areas with higher prepayment shares, and, likewise, declining rates decrease rent growth in areas with higher prepayment shares. The point estimates imply that for a 1 ppt increase in rates in a city with 5% of loans prepaying or maturing, rents would grow 0.3 percentage points more quickly (or vice versa).

I explore the robustness and dependence of these results to the choice of dataset. I show the dynamics of the effect on rent growth in Appendix Table E7. The financing cost effect is not significantly different from zero before year t, and grows through $t+2$. I provide results from regressions where rent growth is determined using a repeat-rent index from REIS in Table E8. The results are similar in direction and significance to Table 6. The magnitude of the interaction coefficients is somewhat larger in the REIS regressions than in the Census regressions, which may be due to the fact that asking rents (particularly on higher-quality, market-rate buildings) are more volatile than the distribution of existing rents overall. Notably, the effect of share prepaying and maturing is positive in these results, corroborating the property-level asking rent results at refinance and sale, which are both positive. It appears that an increase in financing events that involve appraisals (refinance or sale) leads to landlords increasing asking rents, even conditional on change in interest rates.

7 Discussion

In this paper, I have shown three main results: (1) landlords raise revenues at the time that they refinance a new mortgage or around the sale of a property; and (2) there is a positive relationship between rent growth at the city-level and the interaction between multifamily mortgage origination & existing mortgage rate exposure. I discuss a stylized conceptual framework to interpret these empirical results. At the core of the discussion is that landlords make discrete decisions about updates to their pricing and leasing strategies related to learning new, costly information about their local rental housing markets. Financing costs influence their decisions about updating their pricing and leasing because if they fail to update their behavior, they run the risk of paying liquidity-related costs or they miss out on the opportunity to extract equity from the

[36] The regressions are weighted by the coverage of the Trepp securitized dataset (taking units covered by Trepp as a share of 2000 CBSA population).

property.

The average property cashes out \$2.9 million at refinance, or about \$22 thousand per unit.[37] This is comparable to the average single-family refinance (e.g. \$19 thousand in Di Maggio, Kermani, and Palmer 2020). The event study results suggest that landlords anticipate the ability to cash-out and increase rents and revenues leading up to a refinance. Changes in property revenues and rents may affect the appraised value of multifamily properties, likely because appraisers rely on recent leases and financial statements.[38] Landlords ability to 're-optimize' their rental pricing and leasing can be rationalized by the presence of information costs. For the average 200 unit property who is able to increase revenues by 3% around a financing cost shock, the back-of-the-envelope increase in equity is \$130,000 at refinance.[39] Scaling the revenue effect to the 15,000 properties annually originating new securitized mortgages implies an increase in rental revenues of \$200 million, and an increase in aggregate multifamily values of \$2 billion per year due to the information & financing frictions documented in this paper.

Private sector reports from the revenue management industry can benchmark the size of the property-level results. Industry publications report that adoption of pricing and leasing software can generate revenue gains ranging from 1 to 5% of gross revenues. The main results (3% on average) fall right in the middle of this range.[40] Paying revenue management consultants or acquiring new software could represent real-world examples of the 'information costs' I model above. The adoption and use of algorithmic pricing software is an interesting area for future study. The software could reduce information costs. These pricing and leasing dynamics could involve a costly trade-off for tenants if it effectively creates collusion among landlords in their rent-setting behavior. However, the main results of this paper suggest that tenants and landlords both gain in the two financing cost settings. The number of occupied units rises, suggesting that total welfare increases (even though tenants may pay higher prices on average).

The measurement of the main empirical effects speaks to a higher-level policy question: how do changes in monetary policy and the mortgage market affect inequality (Coibion et al. 2017)? Prior work has clarified the stark disparities by race and income in ability to and speed of refinancing for homeowners (Gerardi et al. 2021; Cloyne et al. 2020; Kiefer et al. 2021; DeFusco and Mondragon 2020). In Figure A3, I highlight that around the Fed's single-family mortgage-backed security asset purchases (QE1) in late-2008 and early-2009, a 1.06 percentage point (106 basis point) wedge opened up between mortgage rates for conforming single-family owner-occupied housing compared with multifamily rental housing. The Fed purchased \$10.5 billion in agency CMBS from March 2020-2021.[41] If monetary policy uses asset purchases in residential mortgage markets, policymakers should account for how the costs and benefits of their policies are shared between homeowners, landlords, and tenants. Over the past 20 years, this paper provides evidence that landlords capture significant benefits from lower rates with mixed evidence that tenants benefit—occupancy increases

[37] See Appendix G.

[38] There is discussion in Online Appendix B and evidence in Appendix F on how appraisers with limited information can over-emphasize the importance of asking rents in valuing multifamily housing. Appraiser bias has been a long topic of study (Geltner 1989; Conklin et al. 2020; Clayton et al. 2001; Calem et al. 2021). Some research on the single-family mortgage market have studied 'de-biasing' appraisers (e.g. Conklin et al. 2020; Agarwal, Ambrose, et al. 2020), there has been less work on multifamily valuation partly due to the difficulty obtaining data linking financial outcomes, rents, and values. Recent papers have proposed regression (Li and Liang 2020) or machine learning algorithms (Kok et al. 2017) to improve appraisal values, often called automated valuation models (AVMs). While the point of this paper is not to provide a new method of appraisal, I provide new evidence on appraisals and point out some issues in multifamily valuation.

[39] Appendix F estimates that the appraisal value-revenue elasticity is between 1 and 1.5.

[40] See e.g. Wendy Broffman, "The Bottom Line on the Revenue Management Industry" Yield Pro, April 1, 2007, https://yieldpro.com/2007/04/the-bottom-line-on-revenue-management/.

[41] See Frame and Steiner (2022); New York Fed, Agency Commercial Mortgage-Backed Securities Operation Results, https://www.newyorkfed.org/markets/domestic-market-operations/monetary-policy-implementation/agency-commercial-mortgage-backed-securities/agency-commercial-mortgage-backed-securities-operations.

in many cases, but asking rents almost uniformly increase as well.

The government sponsored enterprises (Fannie Mae, Freddie Mac, and Ginnie Mae) and their overseeing agencies (FHFA and HUD) have heavily increased their presence in multifamily securitization over the past 15 years. The GSEs have substantial scope to affect mortgage terms and characteristics, setting LTV and DSCR limits on multifamily loans that they purchase. Effectively regulating leverage and cash flow constraints can have important effects on tenants. To my knowledge, the effects on pricing and occupancy have not been explored in depth before this paper. During the Covid-19 pandemic, the GSEs' decision to implement multifamily mortgage forbearance and eviction moratoria likely had a very large impact on both landlords and renters. This paper provides substantial evidence on the role of financing costs and motivates additional work on how landlord-side mortgage shocks affect real rental market outcomes.

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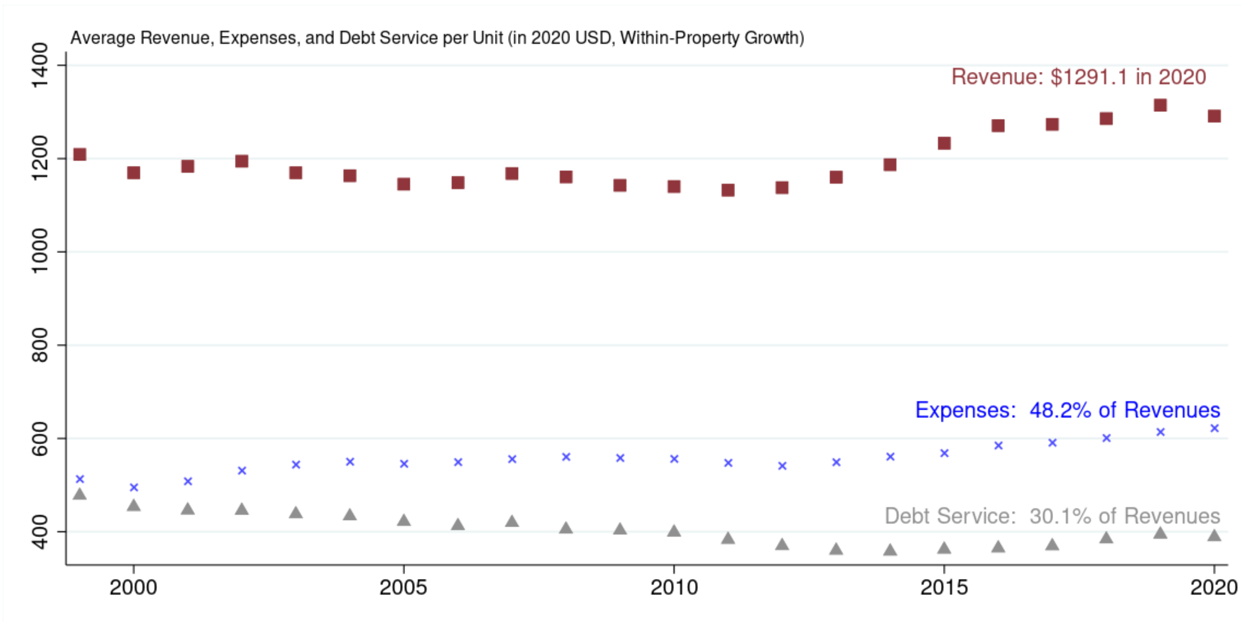
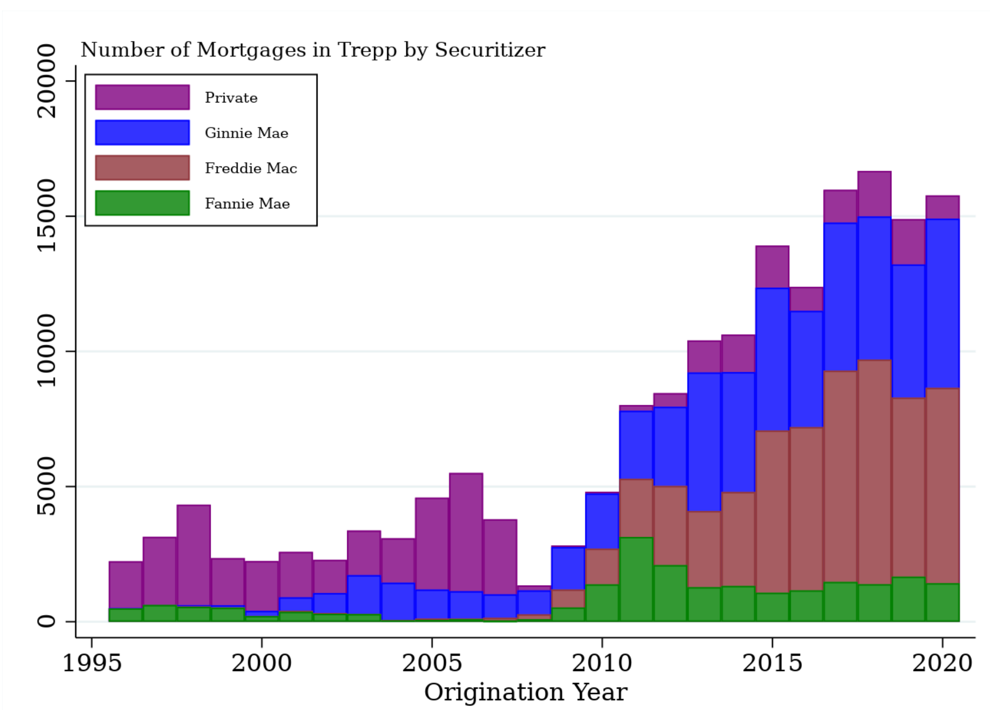
Figure 1: Description of Property-Level Financial Variables & Number of Originations in Trepp Data

(a) Main Financial Variables

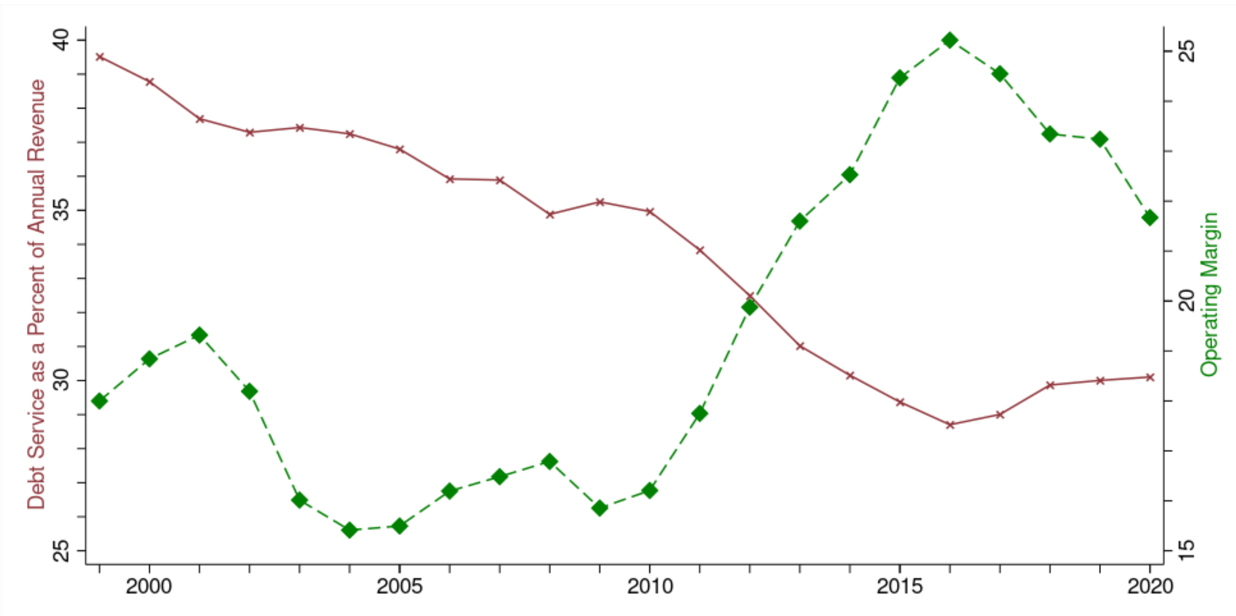


(b) Number of Observations from Private & Agency CMBS



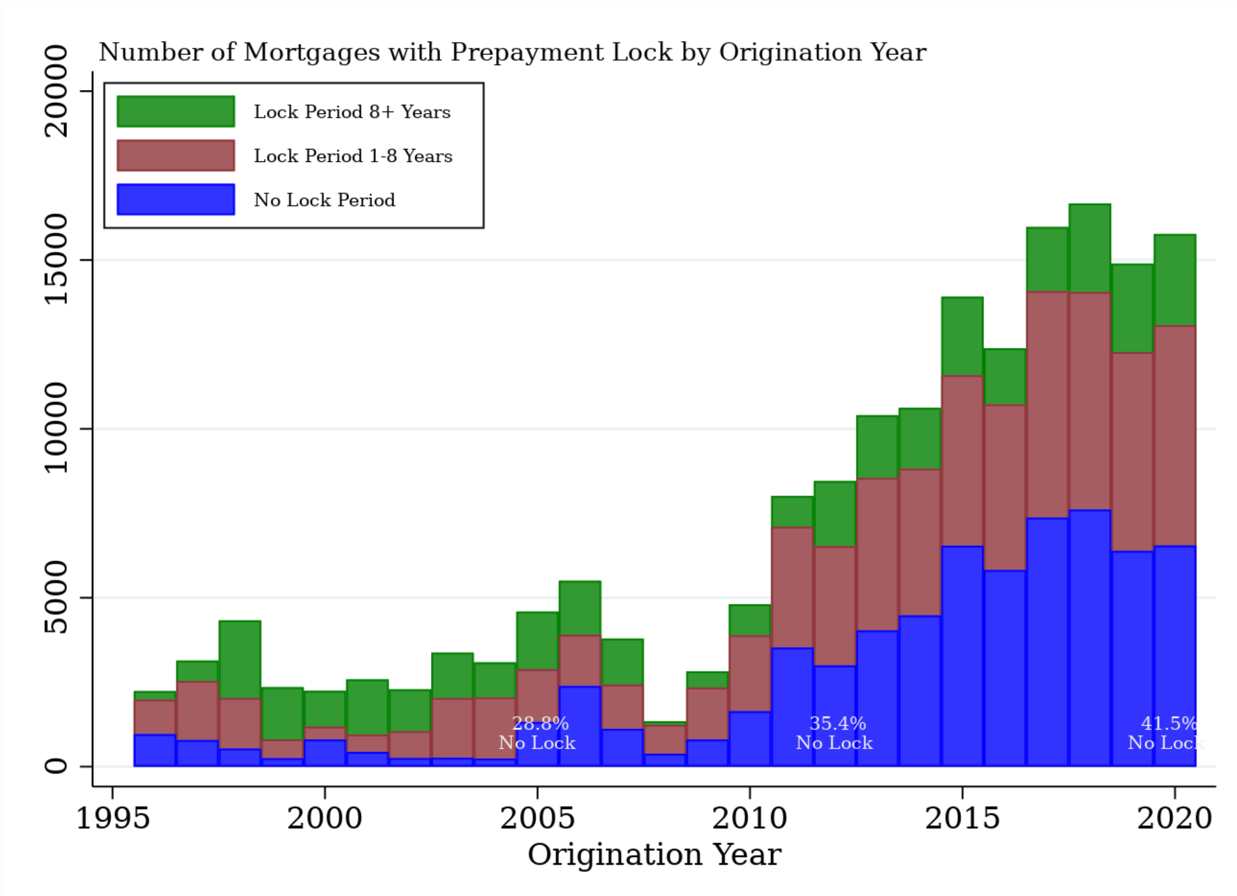
Note: Top panel shows growth in inflation-adjusted average revenues, operating expenses and debt service payments (per unit monthly) using within-property-variation. To do this, I recover constants and year-fixed effects from a regression of each outcome on property fixed effects and year fixed effects. The bottom panel plots the count of newly originated mortgages by origination year in the Trepp CMBS data.

Figure 2: Change in Operating Margin and Debt Service Share of Revenue (using within-property variation)



Note: Figure shows change in annual debt service payments as a percent of revenue and annual operating margin using within-property-variation. Operating margin calculated as revenue minus operating expenses and debt service payments, all divided by revenue. I recover constants and year-fixed effects from a regression of each outcome on property fixed effects and year fixed effects. The left-hand y-axis plots debt service percent in maroon x's, and the right-hand y-axis plots operating margin in green diamonds.

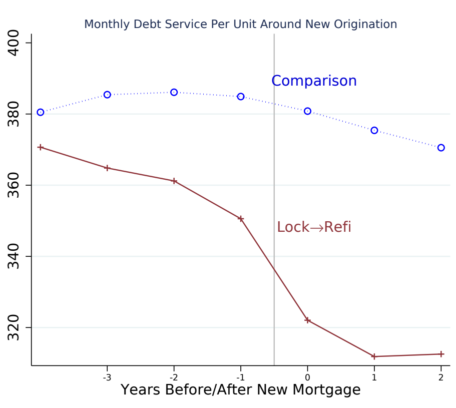
Figure 3: Prevalence of Prepayment Locks for Mortgages



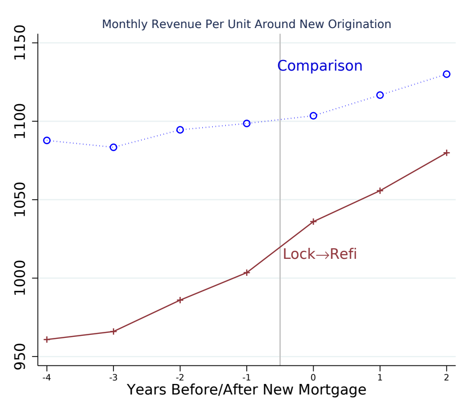
Note: This figure shows the usage and frequency of prepayment lock terms over time for securitized multifamily mortgages. The figure plots the count of newly originated mortgages by origination year in the Trepp CMBS data. I separate three categories: loans with no prepayment lock-out period, those with a lock period of 1-8 years, and those with a lock-out period of 8 or more years. These lock-out periods are bunched at a few numbers of months. Most with 8 or more years locked are for 108 or 114 months out of a total 120 month (10-year) loan term.

Figure 4: Trends in Financial Outcomes for Locked Refinance Mortgages vs Comparison Group

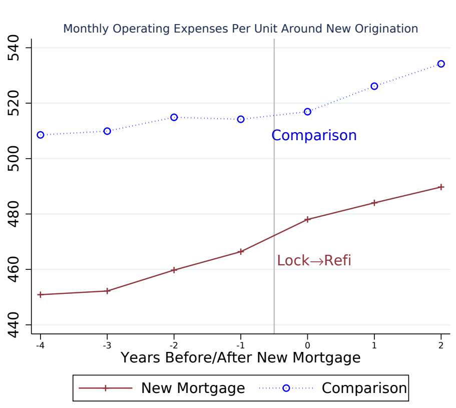
(a) Debt Service Payments



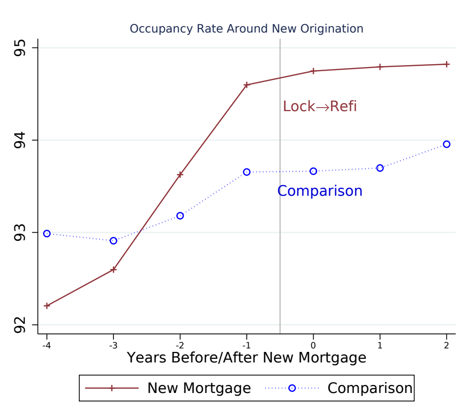
(b) Revenues



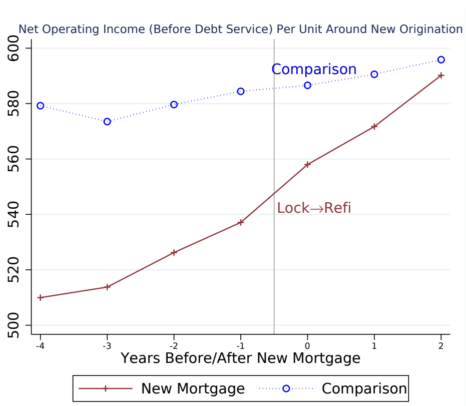
(c) Operating Expenses



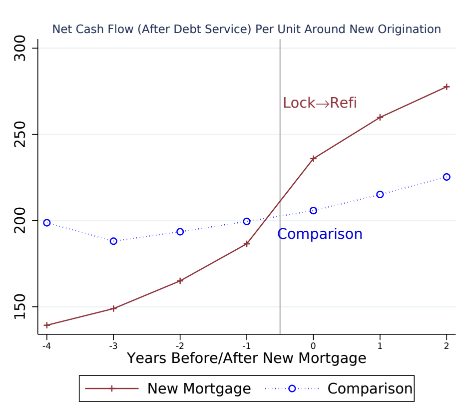
(d) Occupancy Rate



(e) Net Income



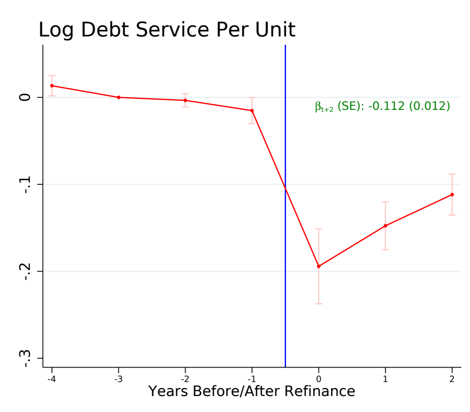
(f) Net Cash Flows



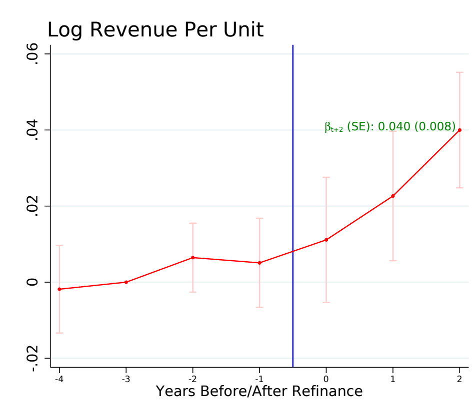
Note: These figures plot average financial outcomes for a panel of properties in the Trepp datasets, where the treated properties are linked across mortgages. The solid maroon lines include properties with prepayment locks on their existing mortgage, where time 0 is the year their existing mortgage prepays or matures. The blue dotted lines represent properties with 10-year loans in the control group, selected for stacked comparisons with the treated lock-refi loans. Each group of control group properties are selected for stacked comparisons with a cohort of treated properties in the lock-refi group. The control group cohorts are balanced in event time in the middle of their current mortgage term (2nd to 8th or 3rd to 9th year), and stacked with a treated group to align in calendar time.

Figure 5: Event Study Results for Locked Refinance Mortgages

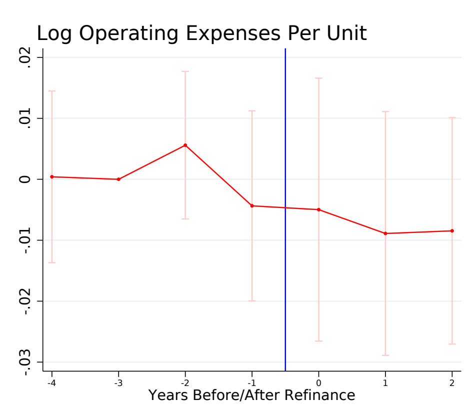
(a) Debt Service Payments



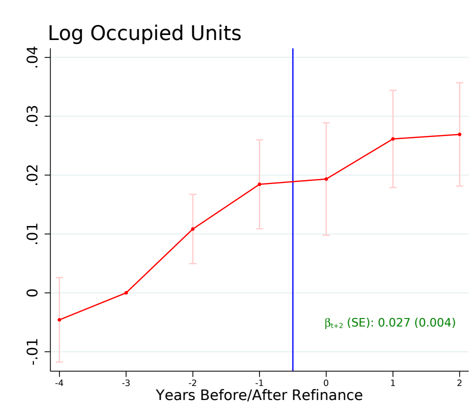
(b) Revenues



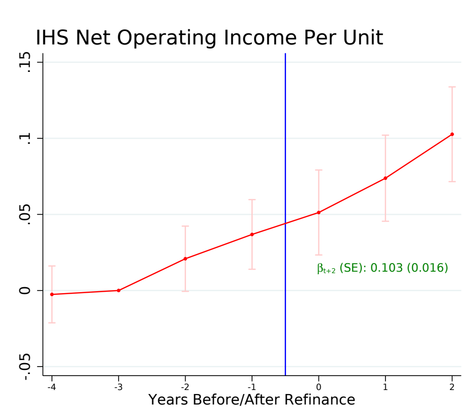
(c) Operating Expenses



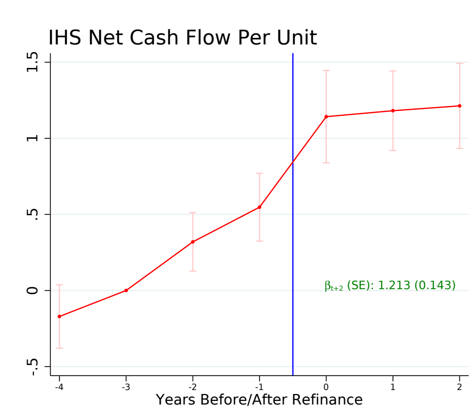
(d) Occupancy Rate



(e) Net Income



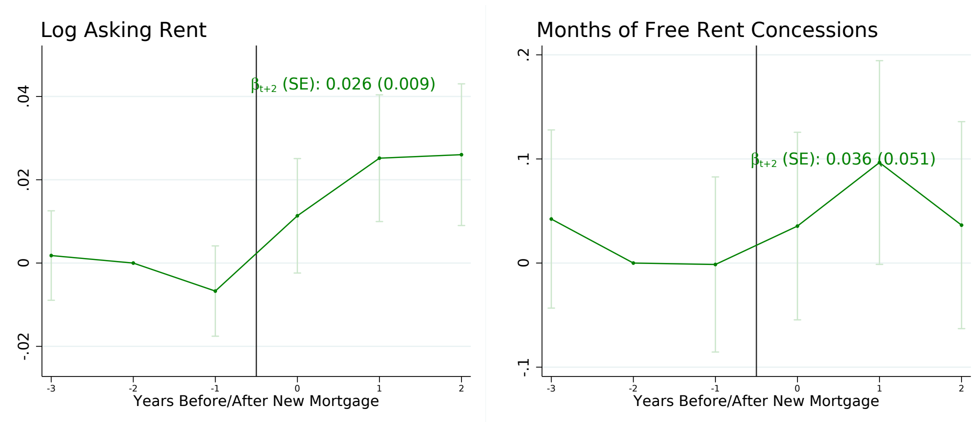
(f) Net Cash Flows



Note: These figures plot event study coefficients for financial outcomes of properties in the Trepp datasets. I compare the treated lock-refi properties to the control group of non-refinanced properties using the regression equation 1.

Figure 6: Landlords Change Asking Rents and Free Rent Concessions at Refinance

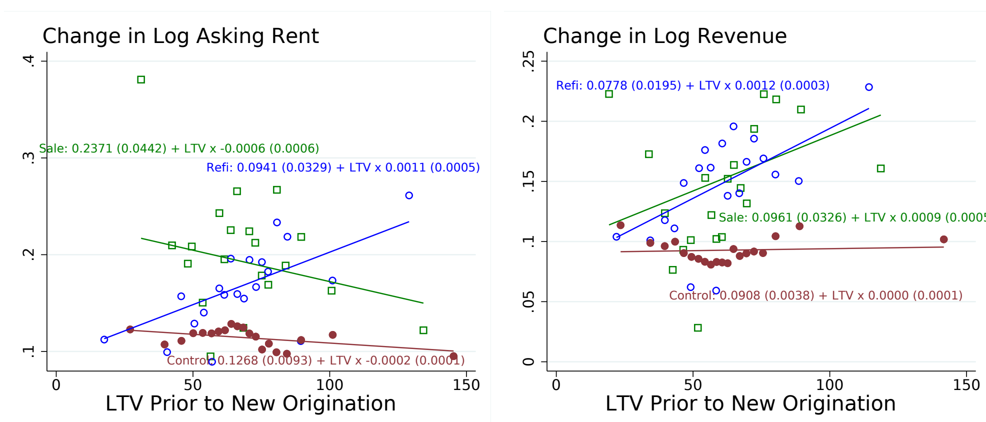
(a) Asking Rent & Free Rent Concessions (REIS)



Note: These figures plot event study coefficients for financial outcomes of properties in the REIS-Trepp datasets. I compare the treated properties undergoing a refinance or sale at time 0 to the control group of non-refinanced properties using the regression equation 1. Appendix Figure C7 includes Trepp financial outcomes to show consistent effects with the Trepp only main effects.

Figure 7: Refinancing Effects Are Related to Leverage

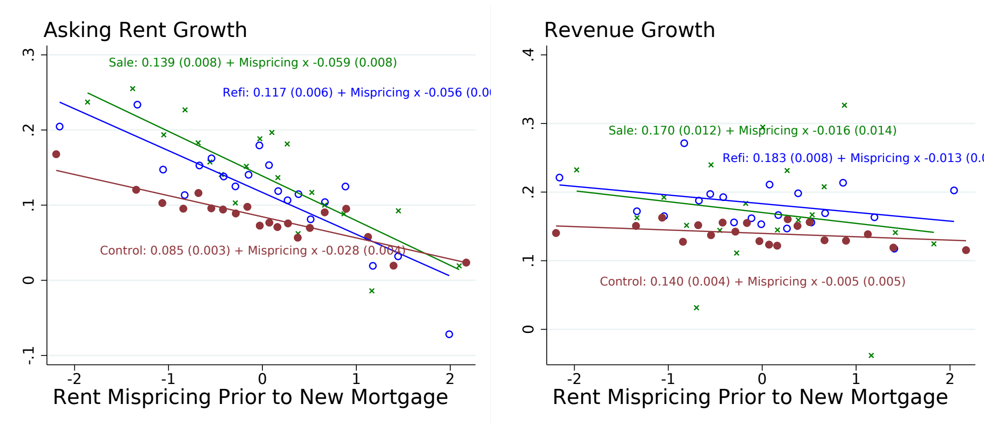
(a) Asking Rent(REIS) & Revenue (Trepp)



Note: These figures plot long differences for market asking rent and financial outcomes of properties in the merged REIS-Trepp datasets. I compare the treated properties undergoing a refinance or sale at time 0 to the control group of non-refinanced properties in long differences from two years before the end the new mortgage is originated to one year after. The x-axis plots a measure of loan-to-value ratio 2 years before the refinance or property sale (where LTV is calculated with the actual remaining loan balance, and projected property value change using the FHFA zip code house price index).

Figure 8: Heterogeneity in Asking Rents by Ex Ante Mispricing from 2 Years Before to 1 Year After Refinance or Sale

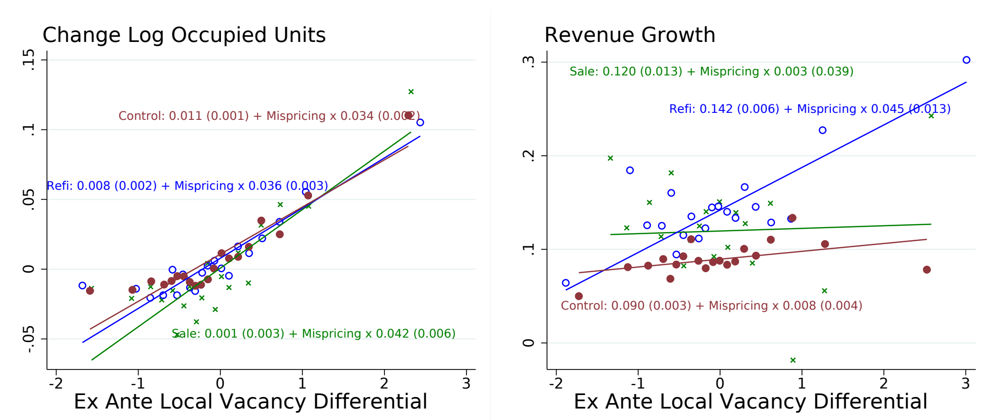
(a) Growth in Asking Rents and Revenue



Note: These figures plot long differences for market rent and financial outcomes of properties in the merged REIS-Trepp datasets. I compare the treated properties undergoing a refinance or sale at time 0 to the control group of non-refinanced properties in long differences from two years before the end the new mortgage is originated to one year after. The x-axis plots a measure of property-level mispricing observed 2 years before the origination. The top panel plots a binscatter of the change in log revenues and log asking rents for the treated and comparison groups. Over the binscatter, I graph a linear regression and report the bivariate regression coefficients for the refinance, sale, and comparison groups. The mispricing measure is the z-score of residuals recovered from a regression of log asking rent per square foot on 23 property amenities and characteristics as well as neighborhood by year fixed effects.

Figure 9: Heterogeneity in Occupancy by Ex Ante Vacancy Differential from 2 Years Before to 1 Year After Refinance or Sale

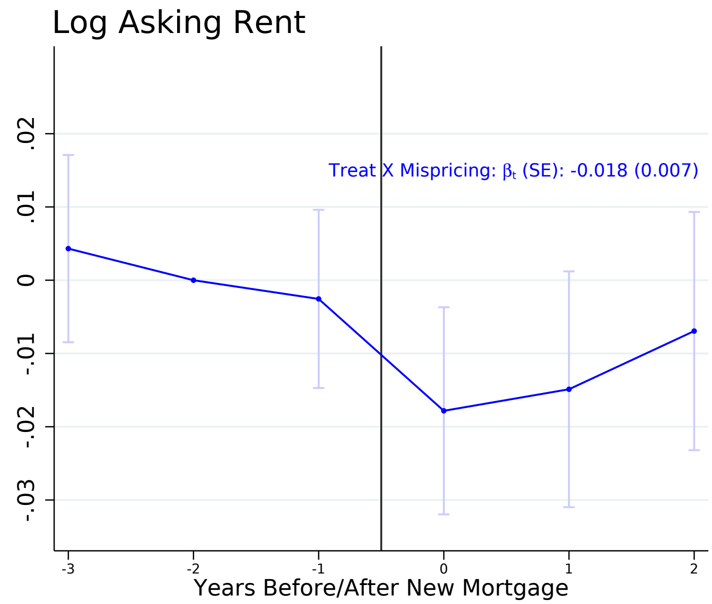
(a) Growth in Occupancy and Revenue



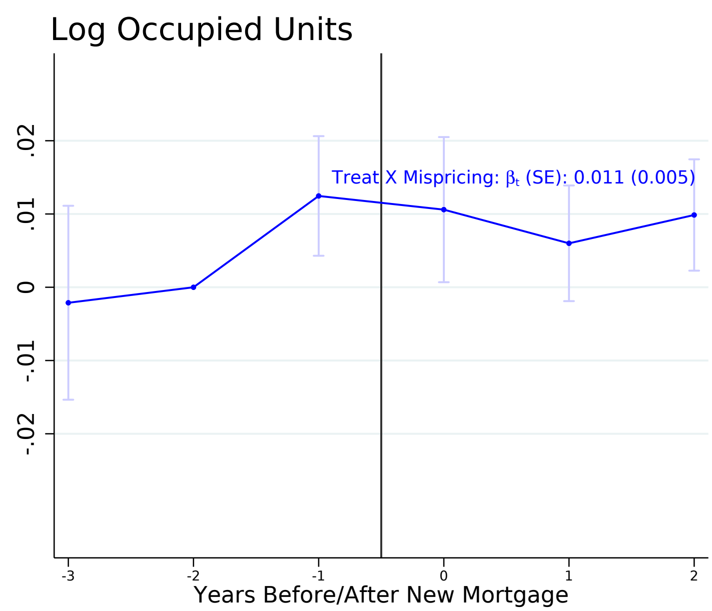
Note: These figures plot long differences for market rent and financial outcomes of properties in the merged REIS-Trepp datasets. I compare the treated properties undergoing a refinance or sale at time 0 to the control group of non-refinanced properties in long differences from two years before the end the new mortgage is originated to one year after. The x-axis plots a measure of property-level mispricing observed 2 years before the origination. The top panel plots a binscatter of the change in log revenues and log asking rents for the treated and comparison groups. Over the binscatter, I graph a linear regression and report the bivariate regression coefficients for the refinance, sale, and comparison groups. The ex ante vacancy differential measure, which proxies for leasing effort, is the z-score of residuals recovered from a regression of vacancy rates on 23 property amenities and characteristics as well as neighborhood by year fixed effects.

Figure 10: Timing Dynamics of Pricing and Occupancy Correction

(a) Change in the Asking Rent-Mispricing Relationship Around a New Mortgage Origination

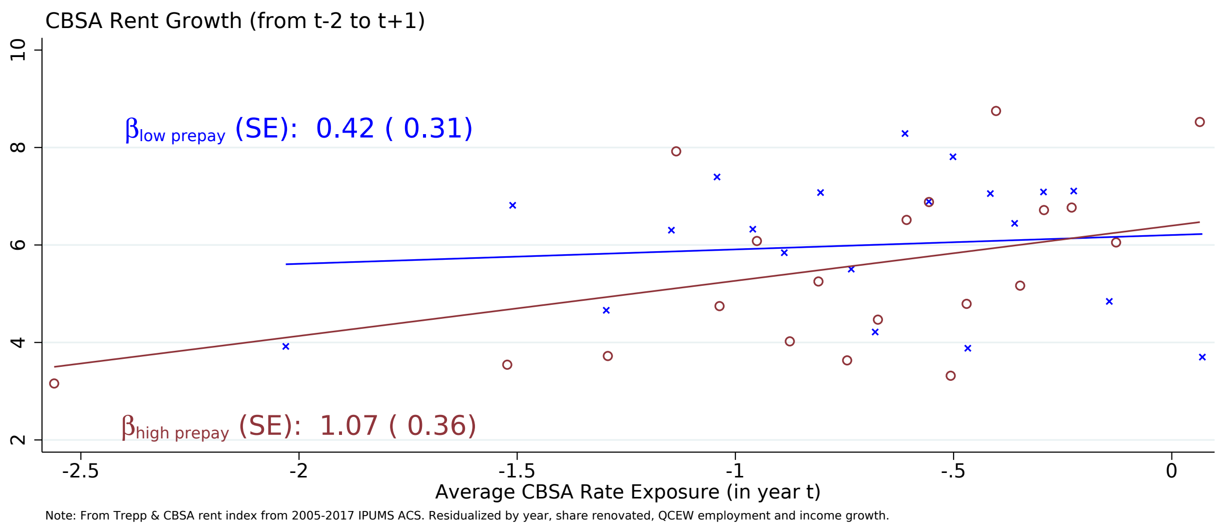


(b) Change in the Occupancy-Vacancy Differential Relationship Around a New Mortgage Origination



Note: These figures plot coefficients $\beta_d^{treatXmis}$ based on Equation (5) using the merged REIS-Trepp datasets. This plots the change for the treated group in the slope of the relationship between the mispricing measure (& vacancy differential measure) and asking rent growth (or occupancy growth). It suggests that treated landlords who undergo a refinance or sale fixed mispricing and underperformance in leasing more quickly relative to the control group who were not refinancing or selling. The ex ante mispricing and vacancy differential measure, which proxies for leasing effort, is the z-score of residuals recovered from a regression of asking rent per square foot (or vacancy rates) on 23 property amenities and characteristics as well as neighborhood by year fixed effects.

Figure 11: Effect of Interest Rate Exposure on Cities with High Versus Low Prepayment



Note: This plots shows the differential change in rent growth for CBSAs in the top versus bottom quartile of originations (measured by the share of existing mortgages prepaying or maturing). The share variable is defined in year t, while rent growth is measured in the years around that, from $t-2$ to $t+1$. Controls include employment and income growth by CBSA over the same period as rent growth (from QCEW), and the share of units renovated in year$t$. Slope coefficients clustered by CBSA.

Table 1: Locked Refinance: Difference-in-Difference Specification

	Debt Service	Revenue	Expenses	Occupied Units	NOI	NCF
Panel A: Log and IHS Specifications						
Post X Refi	-0.125***	0.029***	-0.010	0.022***	0.078***	1.018***
	(0.012)	(0.007)	(0.008)	(0.003)	(0.013)	(0.113)
Obs.	1420444	1420444	1420444	1340250	1420444	1420444
Panel B: Dollar and Level Specifications						
Post X Refi	-37.048***	13.215*	-9.310**	4.162***	22.526***	59.574***
	(4.770)	(7.071)	(3.879)	(0.701)	(6.619)	(7.689)
Obs.	1420444	1420444	1420444	1340250	1420444	1420444
Event-Year-Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes
Property FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are clustered by address. Includes 4 years in event time; 2 years prior to refinance and 2 years post refinance. Relative to refinance year t, specification includes years: t-4, t-3, t+1, and t+2. Treated sample includes 515 properties whose original mortgage had a prepayment lock for more than 80% of the mortgage term, who refinanced and did not renovate the property. The control group sample includes 6,222 properties (some of which are sampled multiple times) in a balanced panel of properties in the middle of their mortgage term who also have a prepayment lock.

Table 2: Heterogeneity in Effect of Locked Refinance: Difference-in-Difference Specification

	Debt Service	Revenue	Expenses	Occupied Units	NOI	NCF
Panel A: Diff-in-Diff Log and IHS Specifications						
Post X Refi	-0.133***	0.031***	-0.009	0.028***	0.087***	1.252***
	(0.013)	(0.008)	(0.009)	(0.004)	(0.014)	(0.134)
Obs.	1357300	1357300	1357300	1280805	1357300	1357300
Panel B: Heterogeneity by LTV and Rate Exposure (Continuous)						
Post X Refi	0.251***	0.022	0.018	-0.026*	0.061	-1.564**
	(0.055)	(0.027)	(0.033)	(0.015)	(0.052)	(0.612)
Post X Refi X Rate Exposure	0.101***	0.022*	0.010	0.007	0.037*	-0.171
	(0.027)	(0.013)	(0.016)	(0.004)	(0.022)	(0.184)
Post X Refi X Existing LTV	-0.339***	0.057*	-0.019	0.089***	0.110*	3.618***
	(0.060)	(0.032)	(0.039)	(0.022)	(0.066)	(0.867)
Obs.	1357300	1357300	1357300	1280805	1357300	1357300
Panel C: Heterogeneity by LTV and Rate Exposure (Discrete)						
Post X Refi	-0.118***	0.022**	-0.011	0.020***	0.071***	0.931***
	(0.015)	(0.009)	(0.011)	(0.004)	(0.017)	(0.134)
Post X Refi X Rate Increase	0.453***	0.074	0.055	0.003	0.134*	0.147
	(0.111)	(0.050)	(0.065)	(0.013)	(0.073)	(0.752)
Post X Refi X High LTV	-0.100***	0.027**	0.000	0.031***	0.047*	1.201***
	(0.026)	(0.013)	(0.015)	(0.008)	(0.025)	(0.329)
Obs.	1357300	1357300	1357300	1280805	1357300	1357300
Event-Year-Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes
Property FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are clustered by address. Includes 4 years in event time; 2 years prior to refinance and 2 years post refinance. Relative to refinance year t, specification includes years: t-4, t-3, t+1, and t+2. Treated sample includes 425 properties whose original mortgage had a prepayment lock for more than 80% of the mortgage term, who refinanced and did not renovate the property. The control group sample includes 6,115 properties (some of which are sampled multiple times) in a balanced panel of properties in the middle of their mortgage term who also have a prepayment lock. Rate exposure is calculated as the change in multifamily mortgage rates between the origination quarter of the prior loan and prepayment or maturity quarter. Rate increase is an indicator variable equal to 1 if rate exposure is positive. Existing LTV is the loan balance two years prior divided by a measure of the current property value (the securitized property value on the prior mortgage times the increase in a zip code-level FHFA house price index since the origination year). High LTV is an indicator for existing LTV greater than 80%.

Table 3: Effect of Refinance and Sale, Controlling for Renovations: Difference-in-Difference Specification

	Debt Service	Revenue	Expenses	Occupied Units	NOI	NCF
Panel A: Diff-in-Diff Log and IHS Specifications						
Post X Refi	-0.121***	0.034***	-0.003	0.024***	0.090***	1.096***
	(0.013)	(0.007)	(0.008)	(0.003)	(0.014)	(0.120)
Post X Sale	-0.117***	0.027***	-0.006	0.015***	0.076**	1.367***
	(0.026)	(0.010)	(0.012)	(0.005)	(0.030)	(0.224)
Renovation	0.067***	0.044***	0.007	0.001	0.101**	-0.050
	(0.026)	(0.012)	(0.012)	(0.007)	(0.039)	(0.193)
Obs.	1195372	1195372	1195372	1117788	1195372	1195372
Event-Year-Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes
Property FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are clustered by address. Includes 4 years in event time; 2 years prior to refinance and 2 years post refinance. Relative to refinance year t, specification includes years: t-4, t-3, t+1, and t+2. Treated sample includes 858 properties. The control group sample includes 5,520 properties (some of which are sampled multiple times) in a balanced panel of properties in the middle of their mortgage term. This sample only includes loans refinanced or sold after 2007 because loan purposes (sale vs refinance) were not reported in prior years.

Table 4: Effect of Financing Costs on Renovation, Acquisitions, and Default

	Continuous				Discrete			
Panel A: Probability of Renovation								
LTV Prior to Orig.	-0.100*	-0.176**	-0.112	-0.303*				
	(0.059)	(0.073)	(0.108)	(0.156)				
Rate Exposure	0.042**	0.068***	0.048*	0.095**				
	(0.020)	(0.022)	(0.028)	(0.036)				
Prior LTV > 80%					-0.051	-0.071**	-0.050	-0.124**
					(0.033)	(0.036)	(0.042)	(0.057)
Rates Increased					0.118*	0.140**	0.100	0.179
					(0.061)	(0.070)	(0.086)	(0.128)
Obs.	1093	1093	1013	702	1093	1093	1013	702
Panel B: Probability of Sale								
LTV Prior to Orig.	0.086	0.147**	0.159*	0.119				
	(0.072)	(0.068)	(0.081)	(0.134)				
Rate Exposure	0.053**	-0.051	-0.055	-0.040				
	(0.026)	(0.035)	(0.040)	(0.058)				
Prior LTV > 80%					0.065*	0.054	0.058	0.057
					(0.035)	(0.033)	(0.038)	(0.054)
Rates Increased					0.174*	-0.001	-0.020	0.026
					(0.103)	(0.111)	(0.126)	(0.111)
Obs.	1093	927	849	623	1093	927	849	623
Panel C: Default, Loss, or Impaired Payoff								
LTV Prior to Orig.	0.146***	0.199***	0.180***	0.063				
	(0.044)	(0.048)	(0.058)	(0.089)				
Rate Exposure	-0.002	-0.008	-0.020	-0.014				
	(0.009)	(0.013)	(0.014)	(0.025)				
Prior LTV > 80%					0.045**	0.061***	0.060**	0.059
					(0.020)	(0.023)	(0.027)	(0.038)
Rates Increased					0.006	-0.010	-0.020	-0.012
					(0.034)	(0.037)	(0.046)	(0.060)
Obs.	1093	1093	1013	702	1093	1093	1013	702
Year FE		Yes	Yes	Yes		Yes	Yes	Yes
Metro FE			Yes	Yes			Yes	Yes
Metro-Year FE				Yes				Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are clustered by core-based statistical area. Sample includes 1,093 properties that are matched across refinance or sale in the Trepp securitized mortgage data, including renovations. Panel B excludes observations before 2007 because the loan purpose is sparsely reported in those years (losing 15% of the sample from 2007 and earlier).

Table 5: Sensitivity of Appraisal Values to Revenues and Asking Rents (Trepp-REIS Merge)

	Change Log Appraisal Value							
Change Log Revenue	1.248***				1.124***			1.576***
	(0.064)				(0.055)			(0.062)
Change Log Expenses		0.482***				0.346***		-0.627***
		(0.109)				(0.129)		(0.056)
Change DSCR			-0.011***				-0.009***	-0.003
			(0.003)				(0.002)	(0.002)
Change Log Asking Rent				0.893***	0.313***	0.820***	0.891***	0.211***
				(0.061)	(0.052)	(0.065)	(0.061)	(0.048)
Change Market Rates	0.016	-0.019	-0.069***	-0.020	0.024**	0.010	-0.022	-0.014*
	(0.011)	(0.019)	(0.018)	(0.015)	(0.010)	(0.016)	(0.015)	(0.008)
Renovation in Prior 3 Years	0.030*	0.050*	0.048*	0.028	0.025	0.030	0.027	0.019
	(0.016)	(0.026)	(0.026)	(0.022)	(0.016)	(0.022)	(0.022)	(0.013)
Any Renovation Since Prior Origination	-0.023	-0.007	0.006	-0.018	-0.028*	-0.024	-0.016	-0.020
	(0.015)	(0.024)	(0.025)	(0.021)	(0.015)	(0.021)	(0.020)	(0.012)
R^2	0.72	0.28	0.21	0.41	0.74	0.45	0.41	0.81
Obs.	627	627	627	627	627	627	627	627

Note: *** p<0.01, ** p<0.05, * p<0.10. Sample includes 627 properties that are matched across refinance or sale in the Trepp securitized mortgage data, including renovations. This includes only properties where the asking rent and financials are observed at the origination of the previous and new mortgage. The within-property long differences show the relationship between appraised values on the properties in securitized loans with the reported financials, binary variables for renovations, changes in mortgage rates between originations, and the change in asking rents.

Table 6: CBSA Rent Growth by Exposure to Interest Rates and Prepayment

	Cross-section			Panel		
Share of Mortgages Prepay/Matured	-7.514**	1.342	-0.411	-3.275	4.677	1.580
	(3.665)	(4.528)	(4.473)	(5.153)	(4.752)	(5.285)
Share X Rate Exposure (Mkt Rate - Act Rates)		13.174***	10.501***		11.501***	6.179***
		(3.663)	(3.567)		(2.925)	(1.021)
Share Renovated			1.549***			1.015*
			(0.502)			(0.473)
Employment Growth			0.143***			0.274**
			(0.038)			(0.088)
Income Growth			0.419***			0.253**
			(0.084)			(0.103)
Obs.	1550	1550	1550	1550	1550	1550
Year FE	No	No	No	Yes	Yes	Yes
CBSA FE	No	No	No	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are clustered by CBSA and year, regression is weighted by coverage of units in Trepp data as a share of CBSA population in 2000. The share of mortgages variable is defined in year t by the share of units in existing mortgages prepaying or maturing, while rent growth is measured in the years around that, from $t-2$ to $t+1$. Rate exposure is the spread between mortgage rates available during year t and actual rates on existing mortgages entering the year. Controls for share renovated in year t, and employment and income growth over the same period as rent growth (QCEW). Share renovated is the share of units with renovation flag in Trepp data in year t.

A Data Appendix

The core of this paper comes from two different datasets: Trepp and REIS by Moody's.

A.1 Trepp Mortgage & Financial Data

The Trepp datasets I use include data on multifamily mortgages in commercial mortgage-backed securities. The CMBS data comes in three different cuts of data, which they internally call Loan, Loan2, and Property. Each of the data sources come from different servicing records of property and loan-level reporting. The records come from borrower reporting about the status of their apartment buildings in accordance with guidelines from CREFC (Commercial Real Estate Finance Council), and include information from Servicer Set-Up files, CREFC Loan and Property Periodic Files, and Annex A's.

Trepp Loan includes mortgage characteristics at origination, including variables like interest rates, original term, amortization term, prepayment lock and penalties, payment schedule (including interest only periods), etc. The data is monthly, so it also includes monthly mortgage payments (interest versus principal), whether the borrower is current, delinquent, or in foreclosure/REO. I use this to create (1) a loan-level dataset of mortgage characteristics at origination and securitization; (2) a loan-by-year level dataset of the contemporaneous status of each mortgage at the beginning and end of each year.

The Trepp Loan2 data provides more comprehensive information on the final disposition of the mortgage. I use it to create a loan-level dataset with the final disposition of each mortgage (with missing data for mortgages that are still current as of the end of the dataset). This provides information on the date of prepayment, maturity, or REO sale. It includes specific dollar values for the amount paid off at the final disposition of the mortgage including the balloon/bullet payment at maturity for mortgages that are not fully-amortizing, or the prepayment amount and any prepayment fees or penalties for mortgages that pay off their remaining balance before the end of their term.

Trepp Property provides detailed data about each property that is used as collateral for the Trepp Loan mortgages. It includes property-level geographic detail (addresses, zip codes, city etc.), and characteristics of the property like the original year built, number of units, the year of the most recent renovation, etc. The Trepp Property dataset is also structured as a property-by-month dataset, which Trepp has linked to the Loan & Loan2 datasets with property- and loan-level identifiers. This can be important because a small share of mortgages are backed by multiple properties.

The most useful part of the Trepp Property dataset is the periodic reporting that borrowers provide to their servicers in accordance with CREFC practices. Borrowers report the financial statement outcomes for each property backing a securitized mortgage. Though this reporting is not always done consistently for each property, for most properties this reporting provides a substantial amount of information on the outcomes for most properties. The reporting on each property generally comes in the form of reporting the most recent financial statement data. Some properties report the most recent quarter, but the vast majority report the most recent year of data (and the second and third most recent year). I exclusively use the most recent (and second and third most recent) annual reporting to construct a property-by-year panel of financial statement outcomes. The line-items collected by Trepp Property include annual revenue, expenses, debt service payments, and net cash flows (which include capital reserves and other capital spending). Often the first and last year of the financial statements are missing, because many properties do not report the year in which they originated the mortgage and do not report after the mortgage has matured/prepaid. I can fill in the first year of the mortgage in many cases because borrowers report their most recent financial statements at securitization, which corresponds to the year prior to origination in most cases.

Using some simple address cleaning, I create unique property-level identifiers which allow me to link mortgages and financial statement outcomes across loans. I do additional cleaning to drop matched loans where the number of units in the property changes by more than 2—signifying either a substantial expansion of the property or a mis-matched property identification.

A.2 REIS Asking Rent & Vacancy Data

The REIS dataset that was acquired at Wharton Real Estate for research purposes includes 50 of the largest metro areas, whose geographic areas are defined by REIS internally, but which match up substantially with Census metropolitan statistical areas. The dataset includes only market-rate multifamily properties. This means that it does not include substantially subsidized housing or public housing (e.g. no LIHTC or Section 8 properties). Because it is only multifamily, it includes only properties with 20 or more units. This can mean that the same property has multiple buildings, so it includes the range of multifamily from individual apartment towers to properties comprised by several dozen garden apartments.

For this dataset, my understanding is that REIS collects data only nearly every market-rate multifamily property by calling each property manager or owner to collect the current information on their property's vacancy rate, asking rent by floor-plan (i.e. asking rent for studio, 1-bedroom, 2-bedroom, etc.), and average free rent concessions offered to new tenants. My dataset has vacancy, rent, and concession data for the 4th quarter of every year, meaning a balanced panel dataset (property-by-year) from 2005-2019.

Another useful aspect of the REIS dataset is that it includes whether the property has 22 different amenities. Unfortunately, our dataset only includes the status of those amenities in 2019, not whether they added or changed those amenities over time. The amenity variables include: square footage by floorplan; washer-dryer hook-ups, washer-dryer, common laundry room, clubhouse, parking garage, parking lot, storage room, pool, business center, security with patrol, any security, doorman, pet friendly apartments, tennis courts, internet provided, fireplace, dishwasher, playground, health club or fitness center, patio or balcony, and elevator.

I perform a string merge on addresses from Trepp and REIS, and only analyze merged addresses with a greater than 99 percent match score. I additionally drop properties whose unit count or year built are substantially different.

A.3 Correlation Between Trepp Financials and REIS Asking Rents & Vacancy

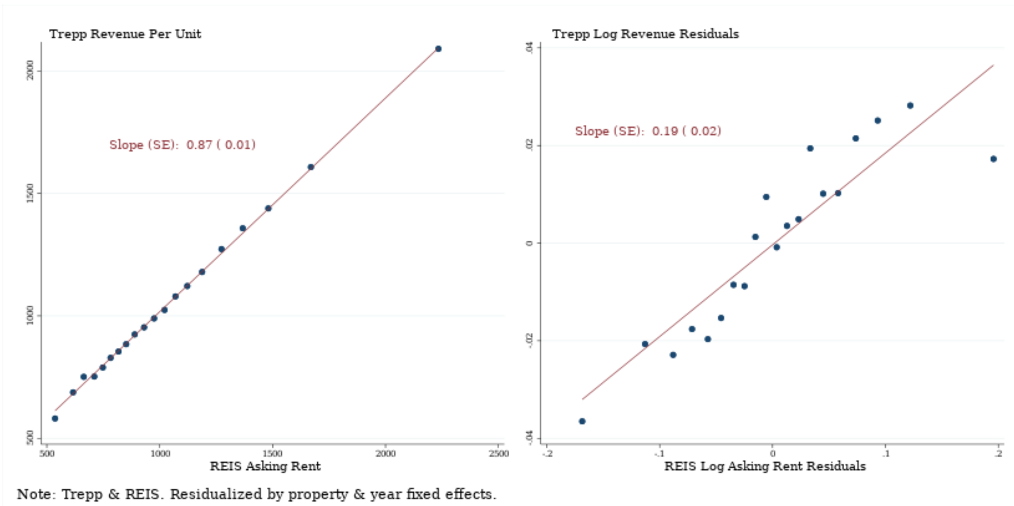
By merging Trepp and REIS data on property addresses, I can compare the levels of revenues and asking rents then show the relationship between changes in asking rents and revenues. Likewise, I can compare vacancy rates reported to servicers during the year with vacancy rates reported to REIS surveys in Q4.

One significant downside of using servicer data to study rental housing markets is that property owners and managers report revenues, expenses, and cash flows for the fiscal year, but only report occupancy rates at points in time (not always for with the same periodicity). This means that in the Trepp data we cannot consistently back out the average rent paid by tenants in the building, and additionally cannot distinguish between asking rents, concessions (free rent), and renewal rents over the course of the year.

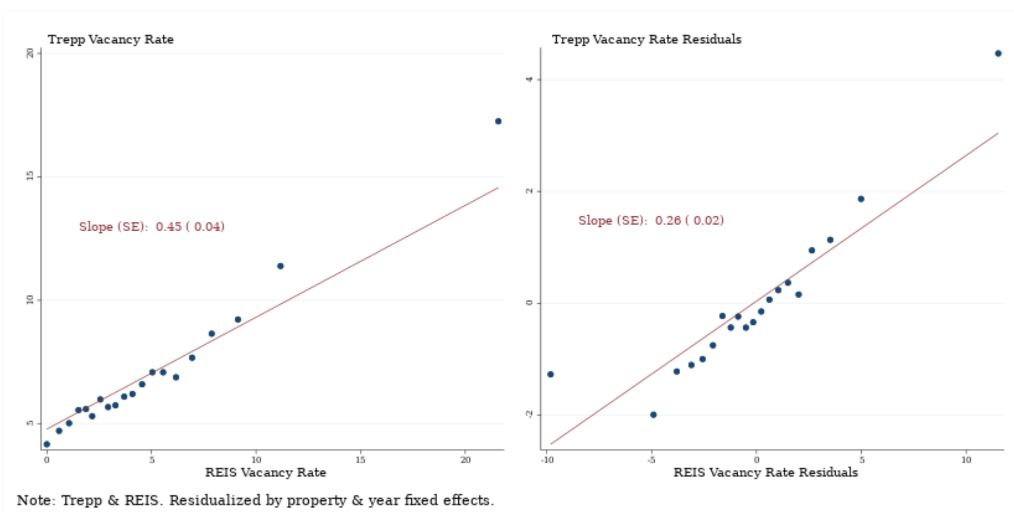
Figure A1a shows that there is a tight relationship between asking rents and average revenue per unit. On average, asking rents are higher than revenues per unit, and one dollar larger asking rents is related to 0.87 cents higher revenues–this could be due to a combination of concessions, vacancy losses, and credit

Figure A1: Description of Merged Asking Rents & Mortgages

(a) Merged Revenue & Asking Rents



(b) Merged Vacancy Rates



losses. In the second panel of figure A1a, I show the relationship using only 'within-variation' by residualizing both variables by property and year fixed effects. This shows a descriptive relationship suggesting that by increasing asking rents by one percent apartment buildings increase their average revenue by 0.19 percent. One potentially meaningful point on this relationship is that industry estimates indicate that around 40% of units turn over each year. If we assume that those 40% of units pay asking rents for half the year (while renewing tenants pay similar rents to the prior year), then an elasticity of around 0.2 is about what we would expect when regressing revenues on asking rents.

Figure A1b shows corresponding correlations between vacancy rates reported to REIS in Q4, and vacancy rates reported by property owners to their servicers (at various points throughout the year). The interpretation of these relationships is less clear, though as a data validation exercise, this seems to suggest that there is meaningful variation in both sources. The vacancy rates from Q4 REIS surveys are substantially lower than the vacancy rates reported to Trepp, especially at lower vacancy levels–while REIS vacancy rates are higher than Trepp rates at higher levels. The slope of the linear relationship between the two is around 0.45. In the second panel, I show the variation between the two vacancy rates residualizing by property and year fixed effects, which shows that the two measures are tightly linked. A one percentage point higher Q4 REIS vacancy rate is related to a 0.26 percentage point higher vacancy rate reported to Trepp (with a standard error clustered by property of 0.02).

The first step in studying the role of financing costs in rental housing is to analyze the cross-sectional relationship between debt service payments and asking rents & revenues, as in Figure A2a. The novel piece of this variation is that I show the change in total debt service payments, and for the same set of properties, I show the change in asking rents. As we would expect, there is a strong positive cross-sectional relationship between rental prices and mortgage payments. Mortgage payments are a reflection of collateral quality/value, market mortgage rates, and endogenous decisions like leverage and terms. We can conclude from this only that there is a strong relationship, likely dominated by the relationship between higher quality properties taking out larger loans.

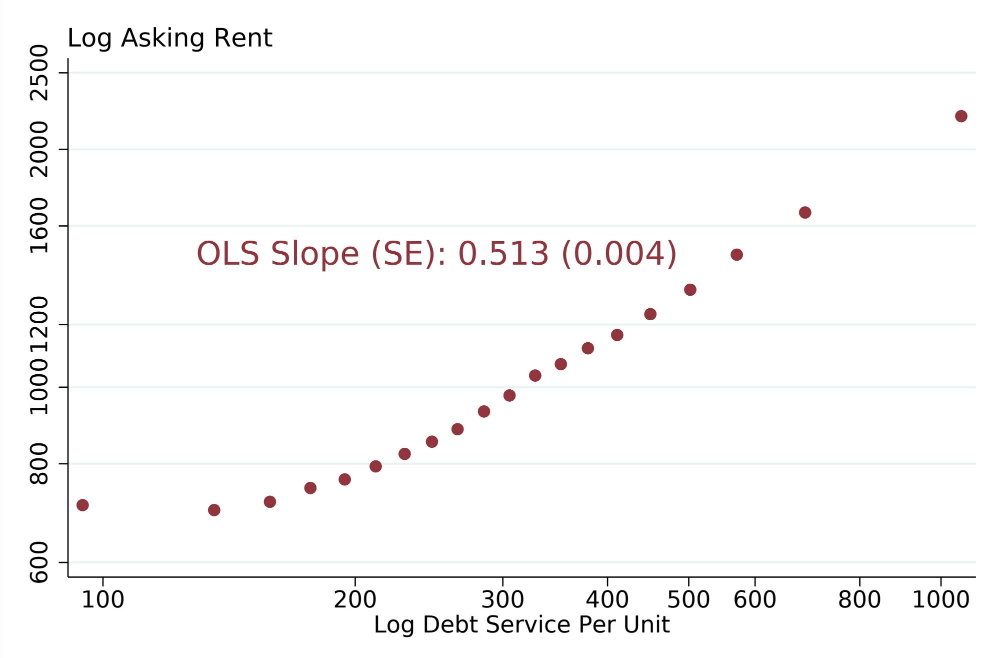
Next, Figure A2b shows the within-property relationship between debt service payments and asking rents. The graph shows a binscatter of the residual relationship, controlling for property fixed effects and year fixed effects. The slope of these relationships imply a 1 percent change in debt service payments is related to 0.02 percent change in asking rents.

A.4 Time Series of Multifamily Mortgage Rates (with Comparison to Single-Family Rates)

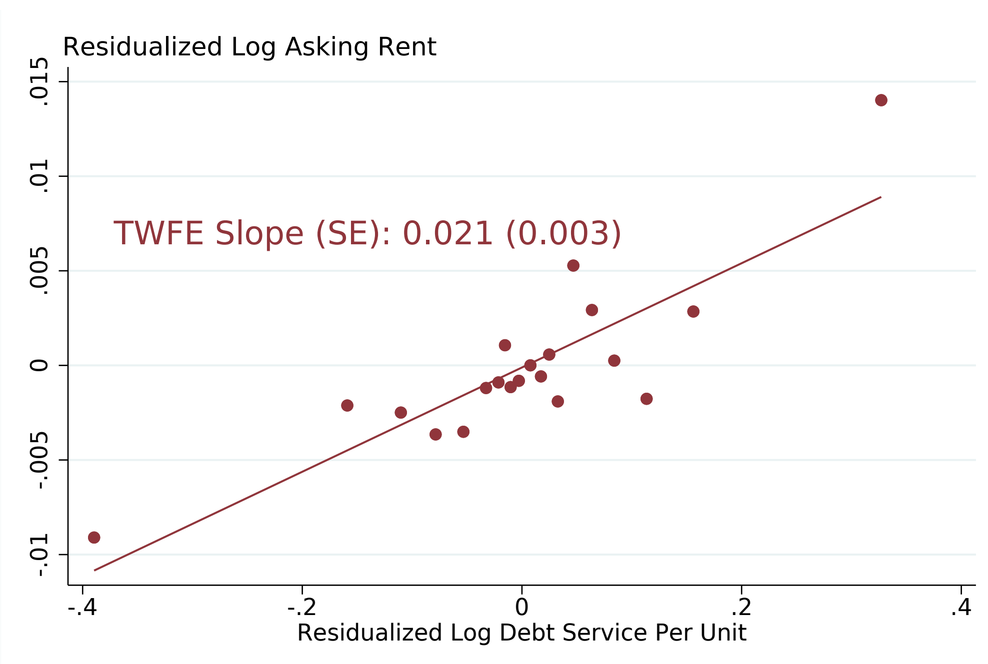
The cost of debt for single-family and multifamily residential housing have been similar over the past 25 years. Figure A3 shows that around the Fed's single-family mortgage-backed security asset purchases (QE1) in late-2008 and early-2009, a 1.06 percentage point (106 basis point) wedge opened up between mortgage rates for conforming owner-occupied housing compared with multifamily rental. As far as I know, this is the first paper to point out this sharp change–though it is similar to empirical relationships documented by Di Maggio, Kermani, and Palmer (2020), which analyze the differential effects of monetary policy on agency-conforming versus non-conforming single-family mortgage origination. The combination of this fact and the observation that GSEs have a 50% market share of multifamily origination suggests that policymakers have a significant role in rental housing markets. This underscores the importance of understanding how shifts in financing costs affect rental housing markets.

Figure A2: Descriptive Relationship Between Mortgage Payments & Asking Rents

(a) Cross-Sectional Relationship

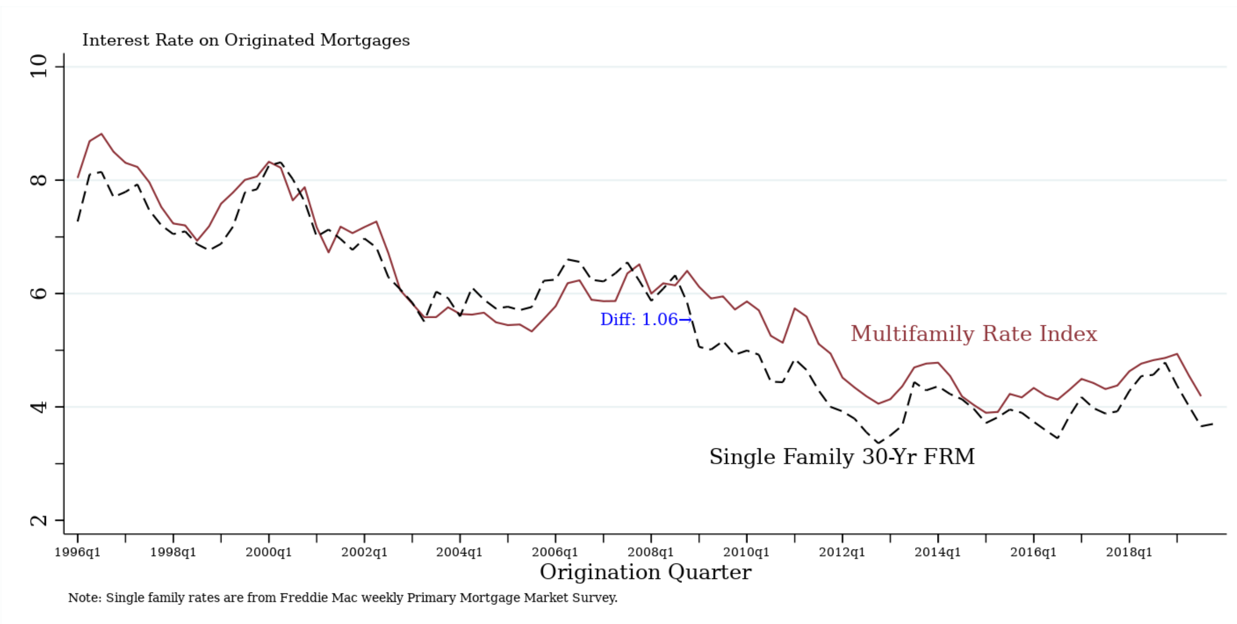


(b) Panel Relationship



Note: Top panel shows cross-sectional relationship between total debt service payments per unit monthly and asking rents. Both variables are transformed with natural logs. The figure shows the labels of each variable in dollar amounts and the slope coefficient from a bivariate log-log regression. The bottom panel plots the residuals after regressing year and property fixed effects on each variable. The coefficient is from the log-log regression with both fixed effects.

Figure A3: Mortgage Rates for Multifamily Rental versus Single-Family



Note: Plots quarterly average single-family fixed rate mortgage quotes from Freddie Mac Primary Mortgage Market Survey in the black dashed line. I create a multifamily rate index using Trepp multifamily securitized mortgages based on recovering the constant and quarter fixed effects from a regression of initial mortgage rates on fixed effects and a vector of mortgage and property characteristics (term, LTV, loan size, property units and age, amortizing, balloon, prepayment penalties/locks, interest-only terms, etc.

A.5 Other Data

There are three sources of rental price data used to study the aggregate effects of financing costs. I create a CBSA-level rent index from (1) REIS property-level asking rents, and (2) Census (ACS IPUMS) micro-data (Ruggles et al. 2022). The REIS rent index is constructed by regressing log asking rents on property fixed effects and year-by-CBSA fixed effects. The Census rent index comes from regressing log of gross rents on several housing characteristics (number of bedrooms, type of structure, etc.) and a year-by-CBSA fixed effect. I take the year-by-CBSA coefficients as the rent index. The ACS-based data gives an average of asking and renewal rents for all types of rental units, while the REIS-based index is only of asking rents for multifamily units. The ACS micro-data covers 2005-2017 and has all CBSAs in the U.S., which is convenient for studying Trepp data on the universe of securitized multifamily mortgages (REIS only includes data on 50 cities).

To study heterogeneity in landlord leverage, I use Federal Housing Finance Agency house price indices at the zip code-by-year level to project property values from their prior origination year to the years before a refinance or sale. This price index was created by Bogin et al. (2019) is a constant-quality house price index based on 97 million conventional mortgages from single-family purchases and refinances. This is useful in that the price index provides a measure of the value of the location increase over time without using any information about each individual multifamily buildings' financials or rental prices. I also use Bureau of Labor Statistics' Consumer Price Index for all Urban Consumers (retroactive series, CPI-U-RS) to adjust for inflation, and Quarterly Census of Employment and Wages total private employment and average annual pay by county and year. I aggregate the employment to the CBSA-level, and take weighted averages of annual pay to control for changes in local economic outcomes in studying the effect of financing cost changes on city-level rental prices.

B Appendix: Institutional Details on Mortgages & Valuation of Rental Properties

Appendix B discusses some institutional details about multifamily valuation and appraisal.

When studying landlord behavior around refinances and appraisals, I note several institutional details about mortgages. There are potential issues surrounding the appraisal of multifamily properties that suggests that landlords have incentives to behave strategically in the appraisal and underwriting process. These appraisals and the financial outcomes that inform them are reported on by investors and analysts, who later observe the loan terms and mortgage pools [42]. This could lead to strategic behavior around setting asking rents versus rents for renewing tenants, deferred maintenance or management quality, or the use of opaque rent concessions.

There are several approaches to valuing a multifamily property. The three prominent appraisal approaches are the Cost Approach, Sales Comparison Approach, and Income Approach. While exact appraiser behavior is not readily accessible in this multifamily context, Fannie Mae and Freddie Mac provide guidance and standards for appraising properties backing their mortgages. They require a dated appraisal within six months of the underwriting package for the property being delivered for securitization.

The Cost Approach asks appraisers to estimate the value of constructing or replacing the property, accounting for depreciation since it was originally built, then accounting for the current market value of the land.

In the Sales Comparison Approach, appraisers select at least four comparable, local sales of properties. They develop an income multiplier for each property, based on effective gross income or potential gross rent. The income multipliers are justified based on "similarities and differences that affect value, which may include variations in property rights, financing terms, market conditions, and physical characteristics and the causes of income variation," including amenities [43].

Anecdotally, there appear to be significant information frictions throughout this process. The market for multifamily property sales is relatively thin and information sources are not well-standardized (relative to the single-family residential market). This could contribute to over-emphasis on recent asking rents when appraisers choose comparison properties (Sales Comparison Approach) and perform their market rent projections (Income Approach). Using practices similar to the appraisers, Freddie Mac's internal appraisal review unit transforms PDFs of the prior 3 months of rent rolls into an excel file, sorts the excel file by date of lease signing, then compares the last 3 months of leases for the mortgage pool to the appraisers market rent/gross income analysis. Their standard is that +/- 5% is an acceptable level of difference from appraised market rents [44]. Freddie Mac's internal appraisal team reports that overly aggressive market rents or underestimates of expenses without justification are common problems with appraisals they review [45].

Freddie Mac does not appear to have data on credit losses by property or market, and suggests that firms work to develop such a database. This implies that renter 'defaults' and formal or informal evictions are not incorporated into the appraisal or underwriting process. Given that the GSEs lack credit loss data, it also may imply that the capital markets have limited scope in measuring and tracking property-level risk premium or cash flow variance. In valuing properties as financial assets, this creates a potential wedge

[42] See: https://assets.ctfassets.net/dqx4ywg83raq/5L1kK7OgxZhmXMvxZxbc1S/824110d982491b0b3544a387460c1cf2/392722.pdf

[43] See: https://mf.freddiemac.com/docs/chapters/mf_guide_ch_60.pdf

[44] See: https://mf.freddiemac.com/docs/appraisal_faqs.pdf

[45] See: https://www.appraisalinstitute.org/assets/1/7/Valuation_Multifamily_Properties.pdf

between the private value to property owner-operators and the valuation of lender/investors.

The approach to estimating gross or potential income using recently signed market rents provides an incentive for landlords to increase their asking rents just prior to re-appraisal. While they are required to report their concessions and free rent to newly-signed tenants, there are widespread anecdotal reports of landlords using creative forms of concessions, like gift cards of equivalent value to several months free rent. One advantage of using something like gift cards is that landlords may be able to classify that under their operating expenses as part of their marketing budget rather than under their gross incomes/base market rents.

A similar perverse incentive is that GSE appraisal guidelines require the consideration of an economic vacancy rate of at least 5%. This means that appraisers first calculate the gross potential income based on rent rolls and asking rents, then to calculate net rental income, they subtract the greater of the 5% of GPR or the actual difference between the trailing 3-month net rental collections (annualized) and GPR. If the property owner's trailing vacancy rate is under 5%, this may provide them an incentive to increase their asking rents (i.e. their GPR) and current vacancy rates if it is near or below 5% prior to appraisal.

These factors deal with the gross potential rent calculated at the time of appraisal, whereas a second issue arises when appraisers or underwriters create a pro forma for the property over the loan term. These pro formas can be used to assess refinance risk and/or default risk. For nearly all multifamily, Fannie Mae requires an assumption of operating expense growth of 3% annually. For rent growth, in prior years, they assumed a flat 2% growth rate. Going forward from this past year, they will assume a 2% rate for student, senior, and subsidized housing, and ask appraisers to calculate rent growth based on the DUS Gateway property submarket rent growth [46]. This suggests that the base rent for the property is determined by the most recent rent rolls, while the property's rent growth projections are based on its surrounding submarket rent growth. This could create two issues. This procedure is potentially problematic because trailing rent growth may be negatively correlated with future rent growth (particularly for properties whose trailing rent growth exceeds that of properties in its local submarket). The spread between the level of own-building asking rents and same-quality submarket rents affects the property's lease-up rate and vacancy rate, neither of which appear to be systematically incorporated in the appraisal/underwriting process. Likewise, the spread between asking rents and existing tenants contract rents can affect the lease renewal rate (and vacancy rate).

Appraisers and underwriters face difficult problems, one of which is access to reliable data. Anecdotally, it appears that they rely heavily on recent rent rolls of each building, the two most recent financial statements, and recent comparable transactions from a relatively thin market. If market participants care primarily about the path of cash flows, investors and lenders should similarly weight the level, growth, and variance in cash flows of comparable buildings even if they did not go through a recent transaction. A barrier to incorporating this information is data access and accessibility, where appraisers are directed to use the sales price of comparable buildings, but have little requirement (or ability) to compare the level and path of rents, revenues, losses or expenses to a comparable group of buildings.

The GSEs could help break down this barrier. They have data both on a large number of property address-level (a) sale transactions; (b) mortgage transaction/credit events outside of sales; (c) annual property-level revenue and expenses; and (d) detailed property-level annual line-item operating statement data. Most of this data is currently reported inconsistently over time, and structured in a difficult-to-analyze PDF or excel format buried in their investor reporting websites. The GSEs could (a) structure the line-item financial data in a usable format, (b) collect data on asking rents, renewal rents, concessions, and credit losses (like

[46] Submarket rents appear to be asking rents provided by REIS: https://multifamily.fanniemae.com/media/15341/display

evictions or early move-outs); and (c) make this data easily accessible to appraisers, investors, policymakers, and researchers for limited or no cost.

C Appendix: Additional Regression & Event Study Results

Table C1: Heterogeneity in Effect of Locked Refinance: Difference-in-Difference Specification

	Debt Service	Revenue	Expenses	Occupied Units	NOI	NCF
Panel A: Diff-in-Diff Level Specifications						
Post X Refi	-41.089***	13.107	-9.387**	4.727***	22.494***	63.583***
	(5.315)	(8.089)	(4.605)	(0.761)	(7.265)	(8.408)
Obs.	1357300	1357300	1357300	1280805	1357300	1357300
	Debt Service	Revenue	Expenses	Occupied Units	NOI	NCF
Panel B: Heterogeneity by LTV and Rate Exposure (Continuous)						
Post X Refi	76.751***	51.806*	17.700	-1.634	34.106	-42.646
	(19.614)	(28.497)	(19.960)	(2.548)	(21.704)	(27.551)
Post X Refi X Rate Exposure	28.454***	15.565	-1.972	1.093	17.537*	-10.918
	(8.449)	(9.544)	(5.595)	(0.896)	(9.304)	(11.506)
Post X Refi X Existing LTV	-109.256***	-23.564	-41.968*	11.075***	18.403	127.659***
	(21.211)	(32.659)	(24.202)	(2.914)	(24.133)	(30.169)
Obs.	1357300	1357300	1357300	1280805	1357300	1357300
Panel B: Dollar and Level Specifications						
Post X Refi	-36.244***	9.067	-7.100	3.775***	16.167**	52.411***
	(6.277)	(9.020)	(5.414)	(0.824)	(7.821)	(9.205)
Post X Refi X Rate Increase	134.269***	50.653	6.458	2.387	44.195	-90.073
	(36.877)	(31.516)	(19.513)	(3.149)	(33.396)	(58.198)
Post X Refi X High LTV	-30.961***	10.496	-9.254	3.330***	19.750*	50.710***
	(9.780)	(11.506)	(7.066)	(1.268)	(10.857)	(13.140)
Obs.	1357300	1357300	1357300	1280805	1357300	1357300
Event-Year-Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes
Property FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are clustered by address. Includes 4 years in event time; 2 years prior to refinance and 2 years post refinance. Relative to refinance year t, specification includes years: t-4, t-3, t+1, and t+2. Treated sample includes 425 properties whose original mortgage had a prepayment lock for more than 80% of the mortgage term, who refinanced and did not renovate the property. The control group sample includes 6,115 properties (some of which are sampled multiple times) in a balanced panel of properties in the middle of their mortgage term who also have a prepayment lock.

In Figure C6, I report event study regression point estimates around the year of a reported renovation, using variation both within and across mortgages.

Figure C7 replicates the main refinance event studies using the Trepp-REIS merged subsample. The results are consistent with the main effects of refinancing on revenues and debt service.

Table C2: Heterogeneity in Effect of a New Mortgage: Difference-in-Difference Specification

	Debt Service	Revenue	Expenses	Occupied Units	NOI	NCF
Panel A: Diff-in-Diff Log and IHS Specifications						
Post X Refi	-26.357***	11.389**	-10.785***	4.030***	22.174***	48.531***
	(3.932)	(5.717)	(3.253)	(0.555)	(5.177)	(6.057)
Renovation	19.702**	42.469***	1.512	-0.458	40.957***	21.255*
	(7.997)	(10.823)	(5.322)	(0.909)	(10.458)	(11.820)
Obs.	1830212	1830212	1830212	1705772	1830212	1830212
	Debt Service	Revenue	Expenses	Occupied Units	NOI	NCF
Panel B: Heterogeneity by LTV and Rate Exposure (Continuous)						
Post X Refi	127.524***	74.991***	25.224**	-0.374	49.766***	-77.757***
	(13.803)	(17.195)	(11.463)	(1.729)	(14.932)	(19.231)
Post X Refi X Rate Exposure	20.732***	18.513***	10.930***	0.619	7.583	-13.149**
	(3.958)	(5.081)	(3.380)	(0.574)	(4.648)	(5.690)
Post X Refi X Existing LTV	-185.583***	-54.715***	-29.987**	7.967***	-24.729	160.854***
	(16.925)	(19.971)	(12.688)	(1.973)	(17.911)	(23.201)
Renovation	14.429*	39.490***	-0.211	-0.420	39.701***	25.272**
	(7.520)	(10.835)	(5.285)	(0.899)	(10.516)	(11.612)
Obs.	1830212	1830212	1830212	1705772	1830212	1830212
Panel C: Heterogeneity by LTV and Rate Exposure (Discrete)						
Post X Refi	-16.665***	8.687	-12.133***	3.377***	20.821***	37.486***
	(4.306)	(6.077)	(3.551)	(0.580)	(5.484)	(6.391)
Post X Refi X Rate Increase	73.310***	60.758***	32.324***	1.137	28.435**	-44.875**
	(13.225)	(16.584)	(12.100)	(1.643)	(14.423)	(19.853)
Post X Refi X High LTV	-64.686***	-0.802	-0.864	2.925***	0.062	64.749***
	(7.696)	(9.178)	(5.191)	(1.009)	(9.236)	(10.766)
Renovation	14.523*	40.477***	0.433	-0.375	40.044***	25.521**
	(7.638)	(10.789)	(5.228)	(0.905)	(10.535)	(11.655)
Obs.	1830212	1830212	1830212	1705772	1830212	1830212
Event-Year-Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes
Property FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are clustered by address. Includes 4 years in event time; 2 years prior to refinance and 2 years post refinance. Relative to refinance year t, specification includes years: t-4, t-3, t+1, and t+2. Treated sample includes 1,063 properties are matched across refinance or sale, including renovations. The control group sample includes 8,041 properties (some of which are sampled multiple times) in a balanced panel of properties in the middle of their mortgage term including properties with and without prepayment locks.

Table C3: Share Prepaying and Maturing Has Little Relationship to Employment and Income Growth (Controlling for Fixed Effects)

	OLS	TWFE
Employment Growth	0.001***	-0.001
	(0.000)	(0.000)
Income Growth	-0.001***	0.000
	(0.000)	(0.001)
Obs.	3120	3120
Year FE	No	Yes
CBSA FE	No	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are clustered by CBSA and year. Outcome is share of existing mortgages prepaying or maturing in year t; independent variables are employment growth and income growth from QCEW from time t-1 to t+2.

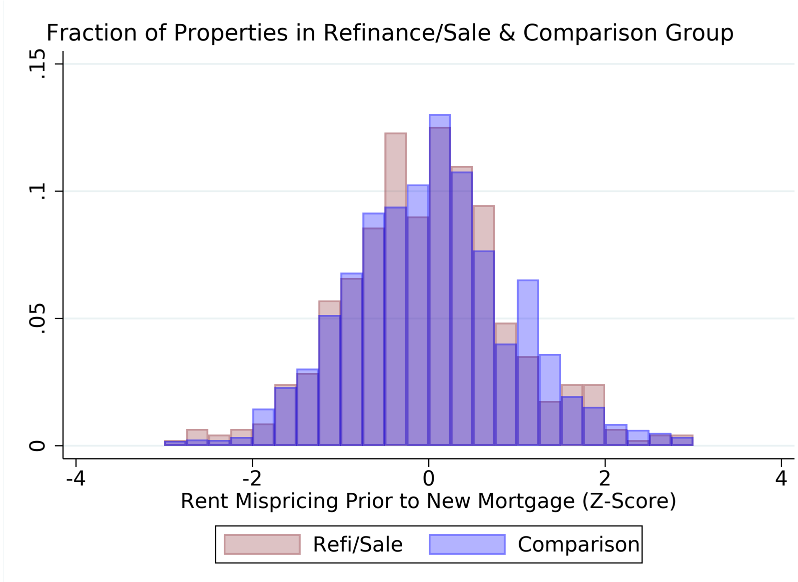
Figure C8 shows the descriptive trends for properties exposed to higher mortgage rates and properties exposed to lower mortgage rates in each of the six outcome variables for refinanced or acquired properties versus the stacked control groups. As in the descriptive trends for locked refinances above, some observations in periods $t = -1, 0$ are imputed linearly based on the nearest neighbors over time for each property. There are 82 properties contributing to the treated group exposed to higher mortgage rates, and 972 properties in the treated group exposed to lower mortgage rates (with 6,938 unique properties contributing to the control group with 18% of those comparison properties stacked to compare to the rate increase treated group).

The original mortgages for the treated groups have lower debt service payments than the comparison group. As expected, after refinance or sale, properties exposed to higher mortgage rates have higher debt service payments and those exposed to lower rates have lower debt service payments. Each series follows common trends in payments for the years prior to the new origination. The right-hand graph shows the trends in revenues. Revenues grow for properties exposed to higher and lower mortgage rates relative to their comparison groups. There do are differences before refinance. Three years before refinance, properties exposed to higher rates have \$50 higher monthly revenues per unit than their comparison group, while properties exposed to lower rates have \$20 lower per unit revenues relative to their comparison group.

In relative terms, properties exposed to higher rates increase their operating monthly expenses by nearly \$20 per unit, while there are no notable differences for properties exposed to lower rates. There are suggestive

Figure C4: Histogram of Ex Ante Mispricing from 2 Years Before Refinance or Sale

(a) Distribution of Mispricing Measure for Properties with a New Mortgage and Comparison Loans Two Years Before Year of New Origination



Note: The histogram is of the distribution of the mispricing measure observed 2 years before the new mortgage origination year with the treated properties in red and control properties in blue. The mispricing measure is the z-score of residuals recovered from a regression of log asking rent per square foot on 23 property amenities and characteristics as well as neighborhood by year fixed effects.

declines in occupancy rates by 0.5 percentage points for properties exposed to higher rates, and increases in occupancy by one percentage point for properties exposed to lower rates.

It is possible that landlords exposed to higher rates anticipate an increase in their cost of servicing debt, and increase their revenues in response. Net incomes and net cash flows increase in the two years prior to refinance for the small group of properties exposed to higher rates. Following refinance, the properties exposed to higher rates experience net cash flow declines, as mortgage payments increase.

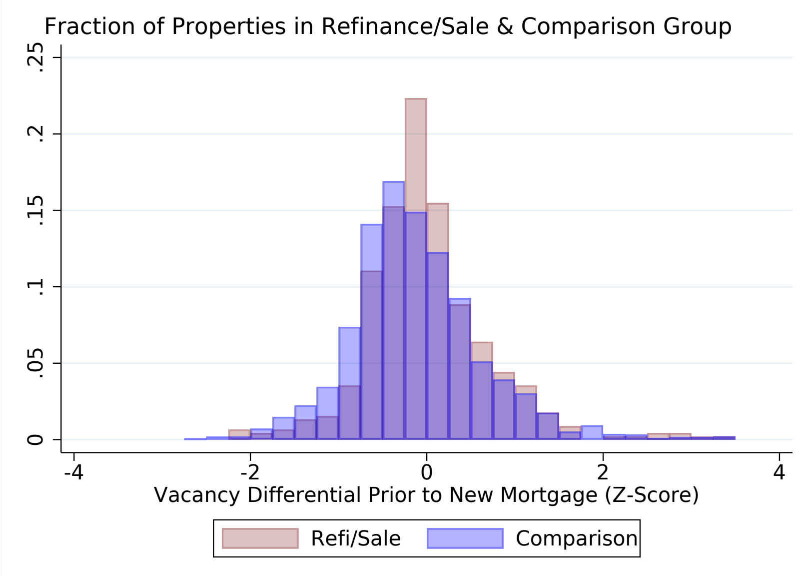
I report the difference-in-difference regressions for this wider set of refinanced and sold properties in Table C4, as described in the section focusing on locked refinance properties. The regression results in dollars and levels is reported in Appendix Table C2. The most important modification of this regression is that I control for the presence of a renovation in the years around the new mortgage origination year (none of the control groups record a renovation in the event window).[47]

Panel A of Table C4 reports the difference-in-difference coefficients which are broadly consistent with the effect of a refinance on the prepayment lock properties in Table 2. Debt service payments fall by 8.9%, revenues grow by 2.8%, expenses decline by 1.2%, and the log of occupied units grows by 2.3%. The renovations coefficients indicate that the average renovation in the sample results in 5.9% higher debt service payments, 4.0% higher revenues, higher expenses and a negligible decline in occupancy. In the appendix version of the table reporting monthly dollars per unit (Appendix Table C2), the average renovation results

[47]To understand the dynamics of the effect of an average renovation, I report in Appendix Figure C6 the coefficients from regressions on the full sample of securitized mortgage data including 4 leads and 4 lags of an indicator variable for the presence of a renovation (the year of the renovation is represented by the indicator variable for time $t = 0$ in this case. The earliest lead and last lag represent average differences in all years early than the 4th year before renovation and 4th year after renovation. The results there are consistent with these average renovation effects.

Figure C5: Histogram of Ex Ante Vacancy Differential from 2 Years Before Refinance or Sale

(a) Distribution of Vacancy Differential Measure for Properties with a New Mortgage and Comparison Loans Two Years Before Year of New Origination



Note: The histogram panel plots a histogram of the distribution of the vacancy differential measure observed 2 years before the new mortgage origination year with the treated properties in red and control properties in blue. The ex ante vacancy differential measure, which proxies for leasing effort, is the z-score of residuals recovered from a regression of vacancy rates on 23 property amenities and characteristics as well as neighborhood by year fixed effects.

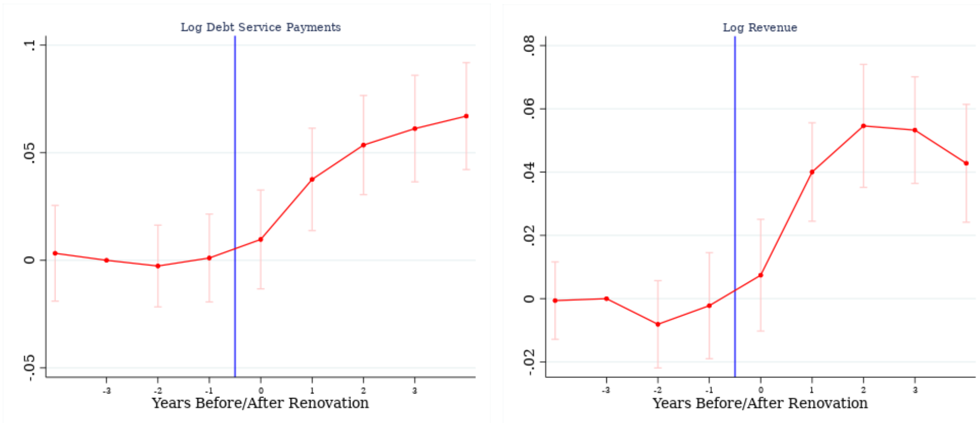
in higher net income and net cash flows, but the coefficients suggest that landlords extract most of the equity from the increase in net income once it is capitalized into the value of the property (i.e. the increase in revenues is partly offset by the increase in debt service payments).[48]

In Panel B, the coefficients on the rate exposure interaction indicate that a one percentage point change in mortgage rates causes an 8.4% change in debt service payments. A 10 percentage point increase in LTV causes a 5.9% decline in debt service payments, suggesting that landlords with higher leverage originate smaller loans. This linear interaction indicates that, compared with the locked refinance results, landlords endogenously timing their refinance or sale are more responsive to changes in equity (and perhaps less responsive to mortgage rate exposure). The coefficient on LTV for locked refinances is 3.4%, while this wider sample has a coefficient of 5.9%. The second column shows that properties exposed to rate increases are able to increase revenues, but column 3 suggests that this may be related to the increase in operating expenses. In both Panel B and Panel C, landlords increase their occupancy when exposed to higher leverage, but changes in mortgage rates have no significant systematic relationship with occupancy. In dollar terms, Appendix Table C2 is broadly consistent with these results, and the results in Panel C suggest that landlords are able to offset 40% of the effect of higher mortgage rates on debt service payments (net income increases by $28.4 per unit divided by a $73 increase in mortgage payments). In contrast, in this setting with endogenous refinance and sale timing, landlords have little change in revenue or expenses from having high LTVs, though they do increase occupancy. The increase in occupancy without a significant change in revenues might imply

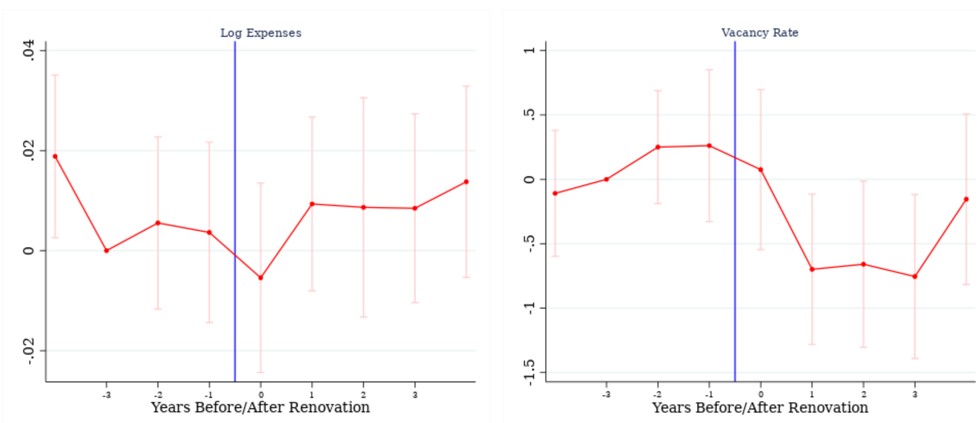
[48]I note that I have excluded any observations where there is a change in the number of units in the building, which could exclude some renovations that increase the size of the property. The main motivation for this exclusion was for data cleaning and consistency purposes, but identifying those types of renovations would be useful in future work.

Figure C6: Event Study Point Estimates Around Reported Renovations

(a) Debt Service Payments & Revenues



(b) Expenses & Occupancy Rates



(c) NOI (Before) & NCF (After Mortgage Payments)

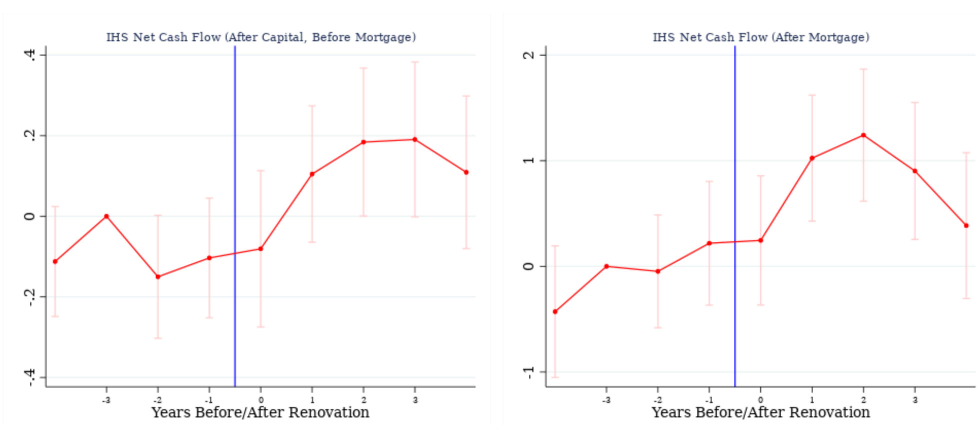
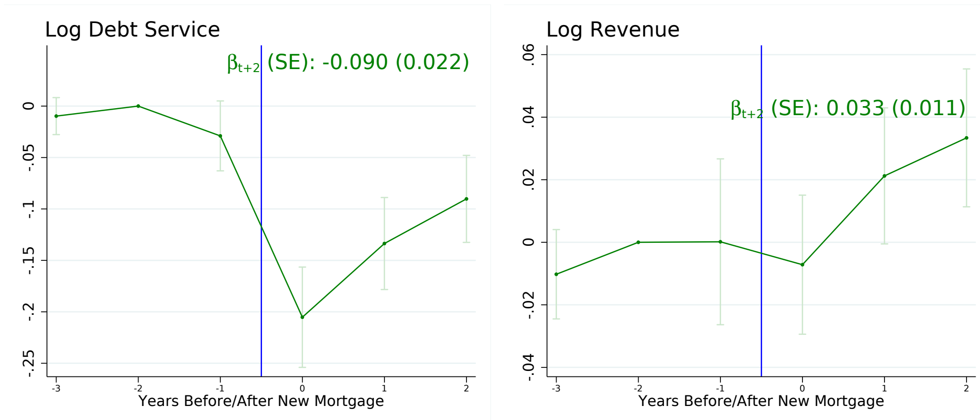
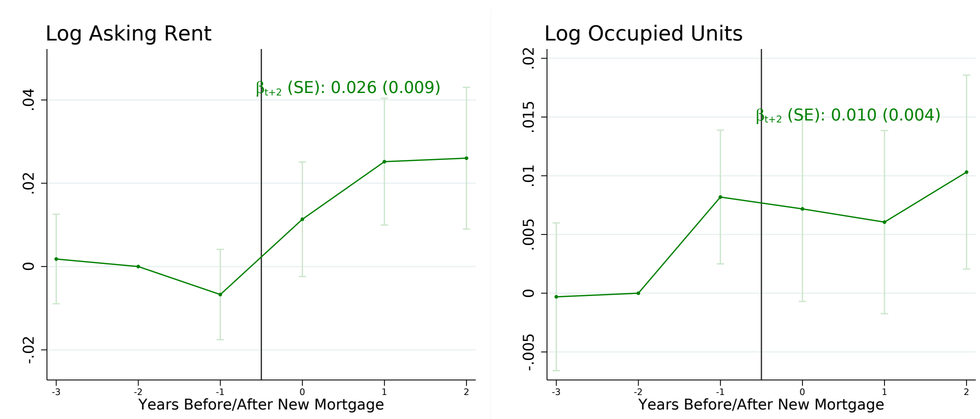


Figure C7: Landlords Change Asking Rents and Free Rent Concessions at Refinance

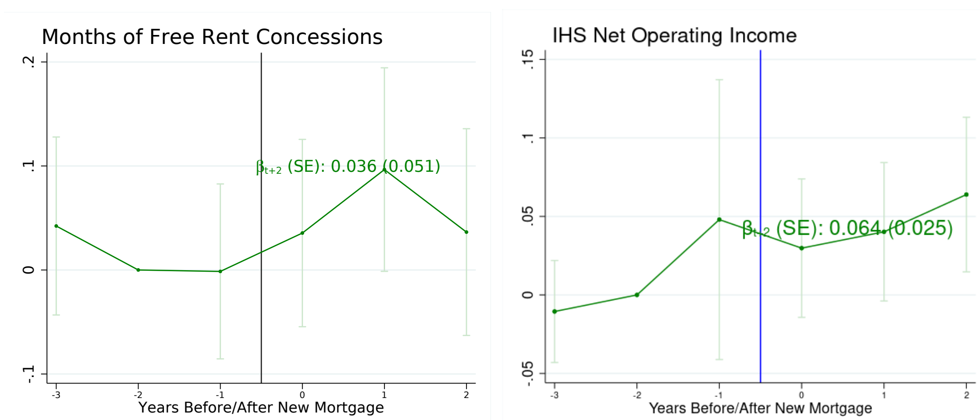
(a) Debt Service Payments & Revenues (Trepp)



(b) Asking Rent & Occupancy Rates (REIS)



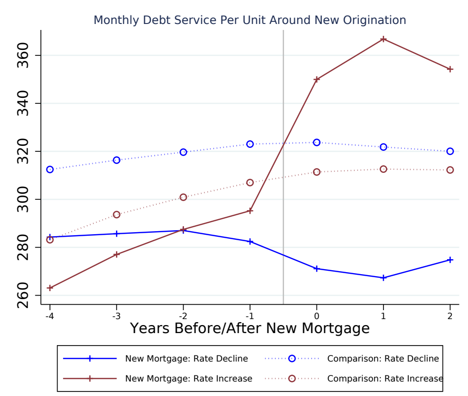
(c) Free Rent Concessions (REIS) & IHS Net Income (Trepp)



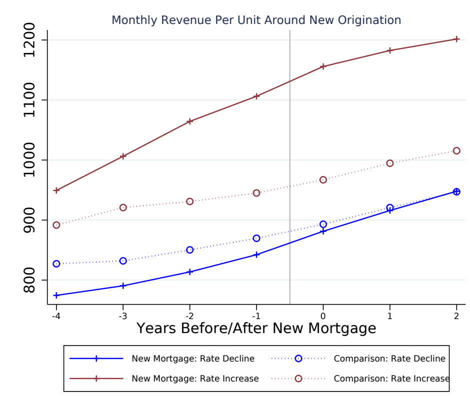
Note: These figures plot event study coefficients for financial outcomes of properties in the REIS-Trepp datasets. I compare the treated properties undergoing a refinance or sale at time 0 to the control group of non-refinanced properties using the regression equation 1.

Figure C8: Trends in Financial Outcomes for all Refinanced or Sold Properties vs Comparison Group

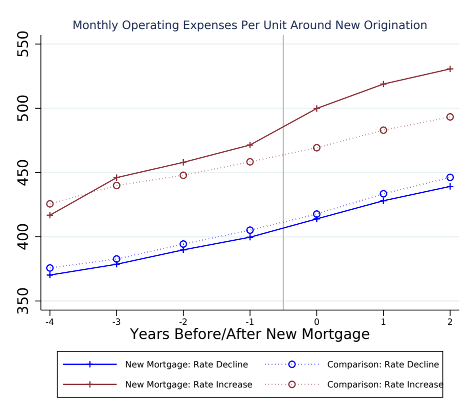
(a) Debt Service Payments



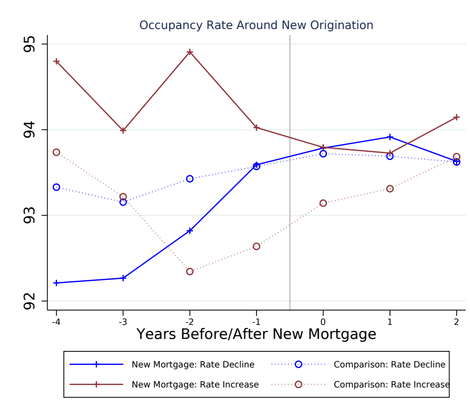
(b) Revenues



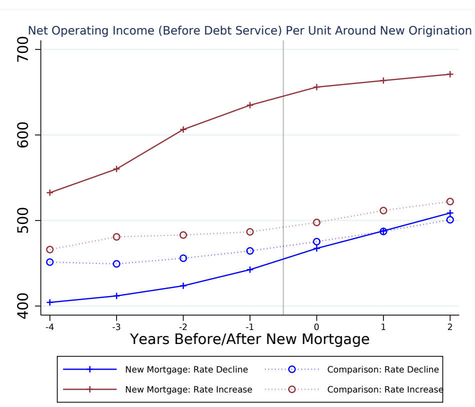
(c) Operating Expenses



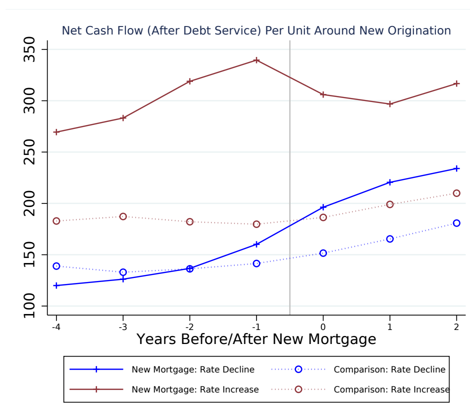
(d) Occupancy Rate



(e) Net Income



(f) Net Cash Flows



Note: These figures plot average financial outcomes for a panel of properties in the Trepp datasets, where the treated properties are linked across mortgages. The solid lines include 1,063 properties are matched across refinance or sale, including renovations. The blue lines represent the control group sample of 8,041 properties (some of which are sampled multiple times) in a balanced panel of properties in the middle of their mortgage term including properties with and without prepayment locks. Rate exposure is calculated as the change in multifamily mortgage rates between the origination quarter of the prior loan and prepayment or maturity quarter of that loan. 'Rate increase' properties are those where rate exposure is positive; 'rate decline' are those where rate exposure is negative. The control group cohorts are balanced in event time in the middle of their current mortgage term (2nd to 8th or 3rd to 9th year), and stacked with a treated group to align in calendar time.

Table C4: Heterogeneity in Effect of a New Mortgage: Difference-in-Difference Specification

	Debt Service	Revenue	Expenses	Occupied Units	NOI	NCF
Panel A: Diff-in-Diff Log and IHS Specifications						
Post X Refi	-0.089***	0.028***	-0.012*	0.023***	0.082***	1.110***
	(0.011)	(0.006)	(0.007)	(0.003)	(0.016)	(0.106)
Renovation	0.059**	0.040***	0.012	-0.005	0.086*	-0.145
	(0.023)	(0.011)	(0.011)	(0.006)	(0.049)	(0.189)
Obs.	1830212	1830212	1830212	1705772	1830212	1830212
Panel B: Heterogeneity by LTV and Rate Exposure (Continuous)						
Post X Refi	0.427***	0.064***	0.036*	-0.009	0.156***	-1.258***
	(0.035)	(0.016)	(0.020)	(0.010)	(0.053)	(0.358)
Post X Refi X Rate Exposure	0.084***	0.018***	0.023***	0.001	0.030	-0.142
	(0.013)	(0.005)	(0.007)	(0.003)	(0.021)	(0.106)
Post X Refi X Existing LTV	-0.590***	-0.015	-0.022	0.050***	-0.047	3.248***
	(0.042)	(0.020)	(0.023)	(0.013)	(0.061)	(0.514)
Renovation	0.040*	0.037***	0.009	-0.004	0.082*	-0.078
	(0.021)	(0.011)	(0.011)	(0.006)	(0.050)	(0.183)
Obs.	1830212	1830212	1830212	1705772	1830212	1830212
Panel C: Heterogeneity by LTV and Rate Exposure (Discrete)						
Post X Refi	-0.064***	0.022***	-0.019**	0.019***	0.078***	0.864***
	(0.011)	(0.006)	(0.007)	(0.003)	(0.020)	(0.107)
Post X Refi X Rate Increase	0.297***	0.063***	0.076***	-0.006	0.087**	-0.368
	(0.043)	(0.017)	(0.023)	(0.009)	(0.041)	(0.313)
Post X Refi X High LTV	-0.195***	0.011	0.017	0.018***	-0.002	1.295***
	(0.020)	(0.010)	(0.012)	(0.005)	(0.026)	(0.252)
Renovation	0.041*	0.038***	0.010	-0.004	0.083*	-0.077
	(0.022)	(0.011)	(0.011)	(0.006)	(0.050)	(0.188)
Obs.	1830212	1830212	1830212	1705772	1830212	1830212
Event-Year-Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes
Property FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are clustered by address. Includes 4 years in event time; 2 years prior& 2 years post. Relative to refinance year t, specification includes years: t-4, t-3, t+1, & t+2. Treated sample includes 1,063 properties are matched across refinance or sale, including renovations. Control group includes 8,041 properties (some of which are sampled multiple times) in a balanced panel in the middle of their mortgage term including properties with and without prepayment locks. Variables defined as in Table 2. Renovation is an indicator variable for whether the property was renovated in the 3 years around a refinance or sale.

a change in landlords' risk tolerance—they may decrease rents, particularly for existing tenants to increase lease renewals.

D Appendix: Behavioral Rent-Setting & Evidence of Frictions in Optimization

This section presents two main pieces of descriptive evidence that many landlords are behavioral rent-setters. They do not seem to optimize their prices and leasing behavior. First, I show a pattern of round-number bias in rent-setting that is common in other pricing and labor markets. Next, I show that there is significant price dispersion and vacancy rate differences, even between buildings within small geographic neighborhoods. This dispersion is consistent with frictions in optimization that have fairly small consequences because the own-price elasticity of demand is fairly small—between -3 and -5, consistent with Watson and Ziv (2021). I then show the relationship between price dispersion and round number bunching, showing that when landlords appear to under- or over-price asking rents in their neighborhood, they are partially correct it over the next year. And if they over-price rents, they more likely to keep rents the same over the next year.

Round-number bias can either be a sign of bias on the demand-side which firms take advantage of to raise their profits, or a sign of optimization frictions or information costs on the firm-side that make it difficult or costly to find and set optimal prices. Demand-side round number bias is often characterized by bunching at numbers ending in '9' taking advantage of behavioral consumers. Firm-side round number bias is more commonly found for firms to set prices ending in '0' or '5'.

The intuition between firm-side round number bias is that optimal prices should be a smooth distribution (assuming no bias on the demand-side), but it is costly for managers or firms to find the optimal price. We can think of there being a cost either of acquiring the information to optimally set prices, or a cognitive or time cost for finding the optimal price. Consider a landlord with a fixed number of units in the building who sets a round-number rent and obtains an occupancy rate in that month $R^0 \times o^0 \times N$. There is an optimally-behaving version of that landlord who pays a cost to set rents that should come from a smooth distribution of efficient rents $R^* \times o^* \times N - s$. Then the landlord will only set the optimal rents if $s > (R^* \times o^* - R^0 \times o^0) \times N$. I make two points with this simple framework. The probability of landlords setting optimal rents depends on how responsive the occupancy rate is to a change in rents, so when landlords are facing more inelastic demand the costs of mis-optimizing are smaller. The probability of paying s to find the optimal rent is increasing in the total number of units in the property, suggesting that it is worthwhile for large landlords to pay to optimize rents. Thus far, I have not spoken about the role of operating or financing costs, but I will later in the paper.

In Figure D9a, I show that 4% of properties post asking rents ending in '00' and '50', respectively, consistent with firm-side behavioral price-setting. Given that there are 100 possible right 2-digits, landlords are 4 times as likely to post an asking rent ending in '00' or '50' compared to randomly distributed optimal rental prices. There is little or no evidence of bunching at '99' to take advantage of consumer left-digit bias. This bunching at '0' could be an anomaly of the cross-section that landlords report to REIS, so I take advantage of the panel data to also show the year-over-year changes in their asking rents.

If they are optimally price-setting, we might expect landlords have a smooth distribution of changes in rents over time. Instead, we can observe in Figure D9b that changes in rents bunch around numbers ending in '0' and '5'. The modal year-over-year change in asking rents is '0', which is the posted change in rent for about 6-8% of properties, depending on how the observations are weighted. This is consistent with the literature on sticky rents (see e.g. Gallin and R. J. Verbrugge (2019) or Ozimek (2014)). Building on that, I also observe that the top 100 property managers in 2019 have less bunching at round numbers in asking rents. Figure D10a & D10b shows the last digit in rents for smaller managers compared to the top

100 largest managers in REIS's top 50 metros. Nearly 20% of 2-bedroom asking rents end in '0' for small managers, while just under 16% end in '0' for large managers. For year over year changes in asking rents, large managers are about half as likely to keep 2-bedroom asking rents unchanged. There also appears to be more dispersion in large manager' asking rents, while changes for smaller managers are bunched around small, round numbers (e.g. 10, 20, 25, 50).

The next figures show dispersion in asking rents and vacancy rates within fairly small geographic areas. I use geographic submarkets defined by REIS, which are generally equivalent to neighborhoods within metro areas. I use submarkets that have at least 6 properties built before 2005, so each individual property has 5 competitors to compare their outcomes with in each year from 2005 to 2019. I have measured dispersion in prices and quantities in two different ways. In work that is available by request, I measure it by taking leave-one-out averages of asking rent per square foot and vacancy rates within each submarket, then measuring the difference between each property and the leave-one-out average of other properties in their submarket. The outcome is similar to the measure I use here: I take the residual of two regressions (on log asking rent per square foot and on vacancy rates) including all 22 amenities available in REIS, log of average square feet, log number of units in the property, number of floors & buildings, building age, and submarket-by-year fixed effects. This is similar in spirit to the leave-one-out average approach, but controls for additional variation in unit and building quality.

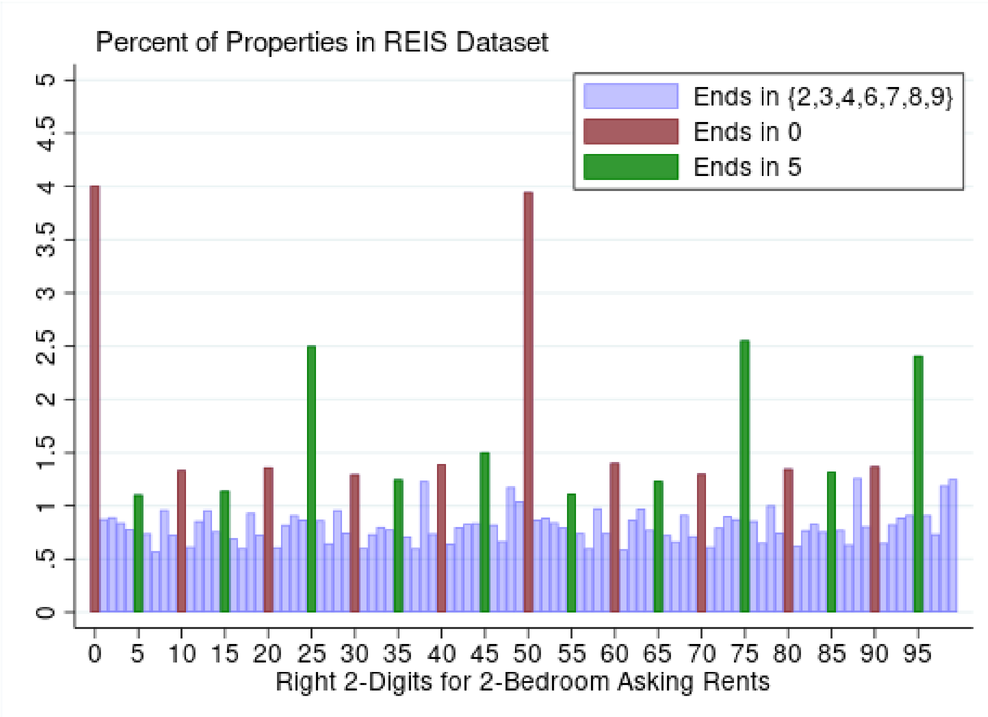
Figure D11a & D11b shows histograms of the residuals from the regressions described above. There is substantial dispersion in both asking rents and vacancy rates. I provide some summary statistics for the size of this dispersion: 25% of properties have rents per square foot more than 0.25 cents from their submarket average (on a sample average of $1.44 per square foot); 36% of properties have vacancy rates more than 3 percentage points (on a sample average of 4% vacancy rates).

In discussing round number bunching, I provide a possible source of this price and quantity dispersion: mis-optimization by landlords, along with market power (that means they face an own-price elasticity of demand less than negative infinity). In Table D5, I show that these measures of dispersion are persistent over time, 1 percent higher mis-pricing last year is related to 0.485 percent higher mis-pricing this year; 1 percent higher vacancy differential is related to 0.324 percent higher vacancy this year. I have focused on discussing landlords mis-pricing, but here I show some suggestive evidence that landlords are making decisions along multiple margins which include at least their pricing and their leasing effort: lagged mis-pricing and vacancy differential are persistent in a way that appears to be independent of each other. Controlling for the lag of both does nothing to affect the coefficients on their lagged values. Higher vacancy last year is related to lower rents relative to nearby properties this current year. Higher rent mis-pricing last year is related to higher vacancy differential this year (which makes sense given the persistence of rent mis-pricing). Consistent with these results, in work available upon request, I show that the probability of keeping the rent the same year-over-year is positively related to lagged rent mis-pricing and negatively related to vacancy differentials (this is one piece of evidence on the stickiness of asking rents).

Table D6 shows the contemporaneous relationship between the residual rents and vacancy rates on log asking rents and vacancy rates controlling for property fixed effects and submarket-by-year fixed effects to establish the multivariate relationships controlling for both the rent and vacancy residuals together. The next columns show the landlords behavior by regressing the change in log asking rent and log occupied units on the lagged values of the mis-pricing residuals and vacancy differentials. We observe that there is a negative relationship between the lagged mis-pricing measure and change in asking rents, suggesting that 1 percent higher mispricing is correlated with 0.5 percent lower asking rent growth, and 1 percent higher

Figure D9: Round-Number Bunching in Asking Rents

(a) Right 2 Digit Bunching of Asking Rents



(b) Right 2 Digit Bunching of Changes in Asking Rent

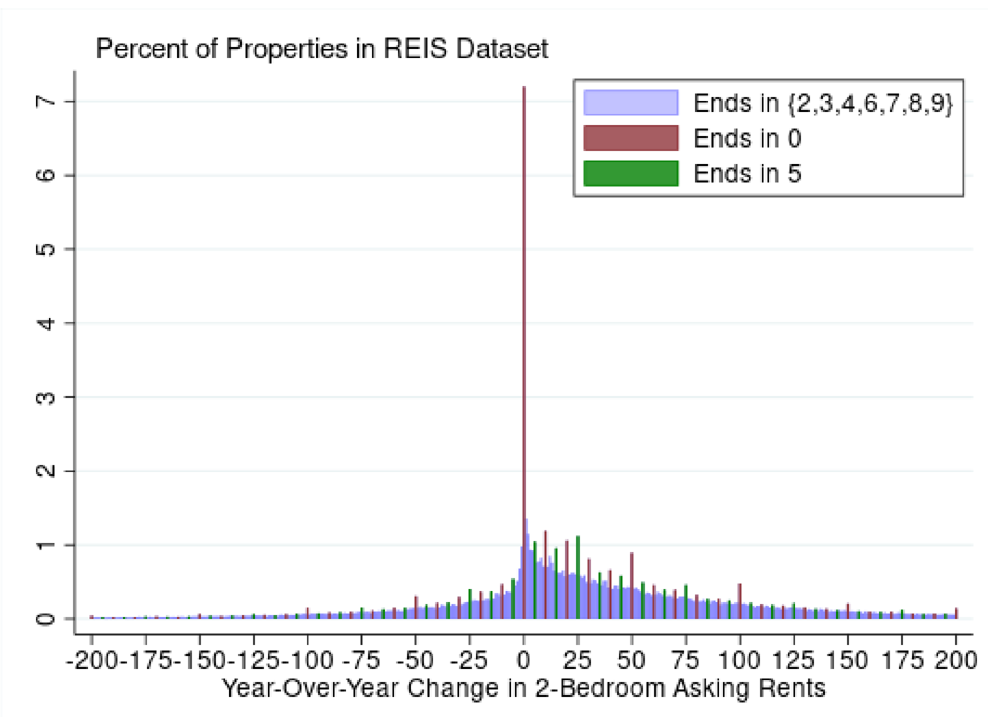
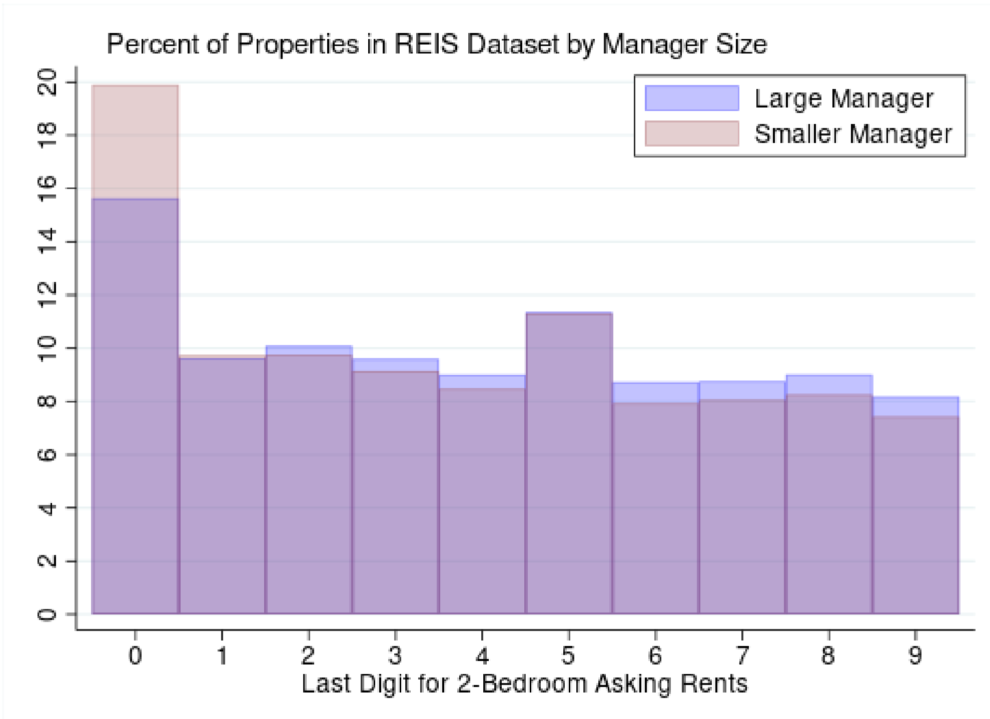


Figure D10: Round-Number Bunching in Asking Rents by Manager Size

(a) Last Digit Bunching of Asking Rents



(b) Right 2 Digit Bunching of Changes in Asking Rent

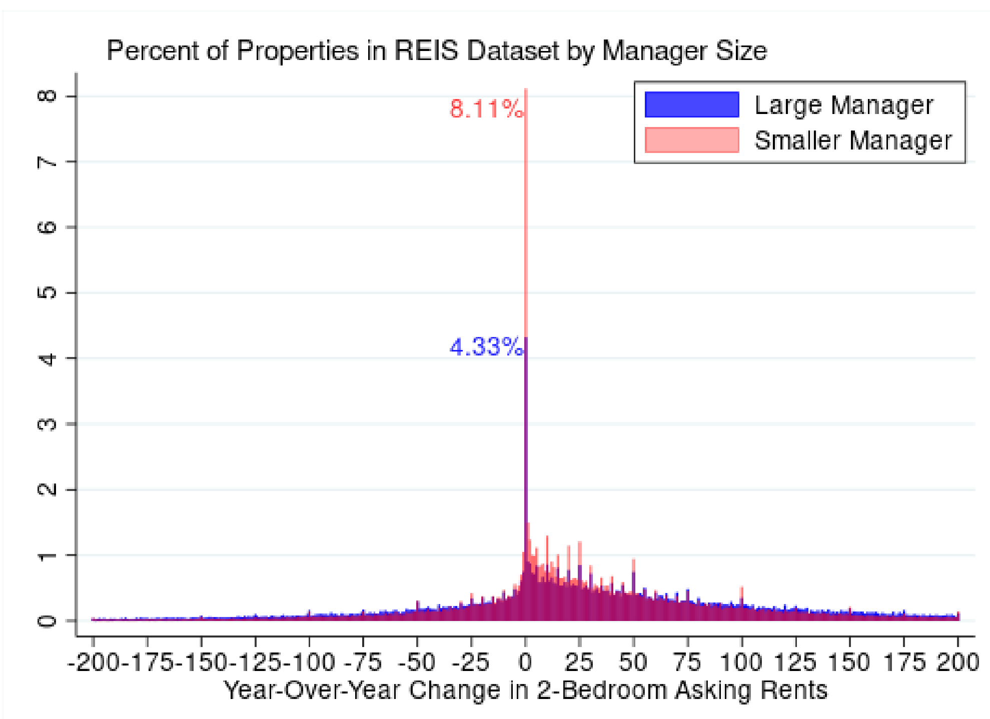
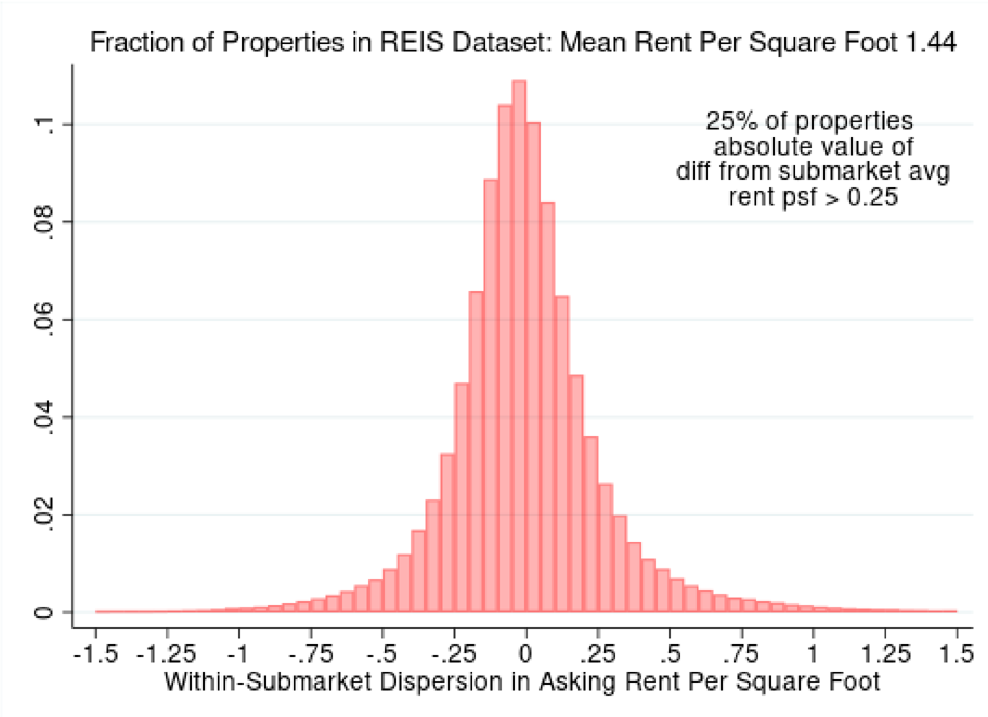


Figure D11: Within-Submarket Dispersion in Prices and Quantities

(a) Asking Rent Per Square Foot Dispersion



(b) Vacancy Rate Dispersion

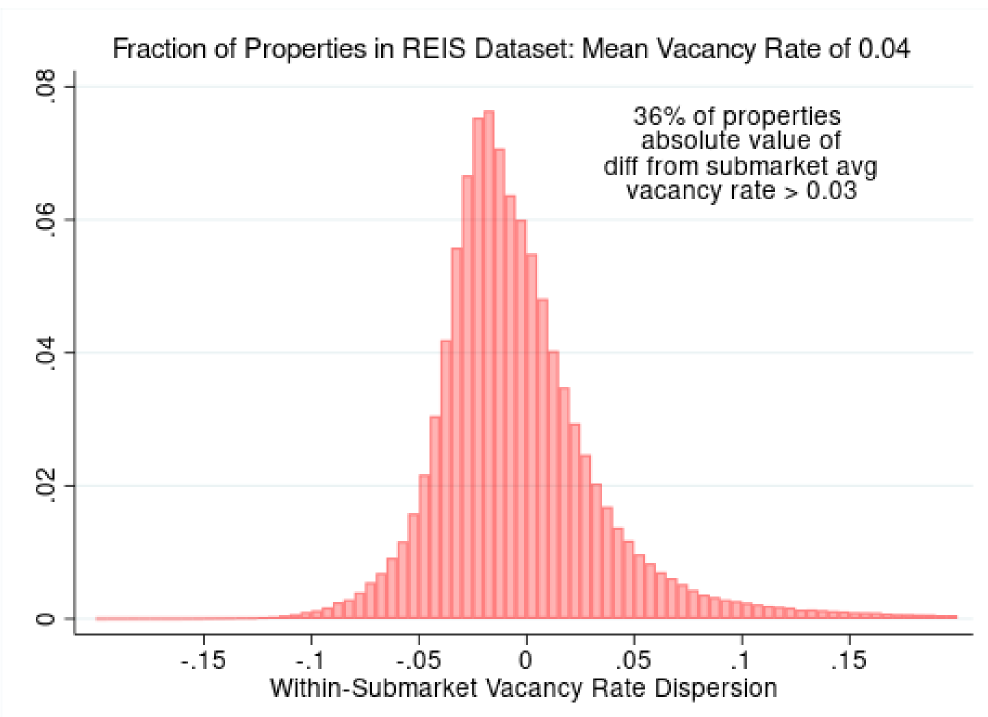


Table D5: Persistence in Asking Rent and Vacancy Differentials

	Current Local Rent PSF Differential		Current Local Vacancy Differential	
Prior Local Rent Mis-Pricing	0.485***	0.485***		0.006***
	(0.002)	(0.002)		(0.001)
Prior Local Vacancy Differential		-0.020***	0.324***	0.324***
		(0.003)	(0.002)	(0.002)
Obs.	392689	392689	392689	392689
Property FE	Yes	Yes	Yes	Yes
Submarket-Year FE	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are robust. Only includes properties from REIS (covering market-rate multifamily with more than 20 units in the 50 largest cities classified by REIS). Local Vacancy Differential & Local Rent Mis-Pricing are the residuals taken from regressions of vacancy rate and log asking rent per square foot on year-by-submarket fixed effects, along with controls for log number of units, floors, buildings, square feet per unit, and 22 different property and unit amenities with a balanced panel of properties within the same geographic submarket.

vacancy is related to about 0.02 percentage points lower asking rent growth. The final column shows that higher rent mis-pricing last year is related to a smaller growth in occupancy (again consistent with stickiness of asking rents), and 1 percent higher vacancy differential is related to around 0.8 percent higher growth in occupancy rates. This suggests that while high and mis-priced asking rents may be persistent, landlords may exert additional leasing effort after high vacancy years to raise their occupancy rates.

Table D6: Current and Prior Year Asking Rent and Vacancy Differentials

	Log Asking Rent	Log Occupied Units	D1.Log Asking Rent	D1.Log Occupied Units
Current Local Rent Mis-Pricing	0.997***	0.000**		
	(0.000)	(0.000)		
Current Local Vacancy Differential	0.002***	-1.164***		
	(0.000)	(0.000)		
Prior Local Rent Mis-Pricing			-0.515***	-0.007***
			(0.002)	(0.001)
Prior Local Vacancy Differential			-0.021***	0.783***
			(0.003)	(0.002)
Obs.	420739	420739	392692	392692
Property FE	Yes	Yes	Yes	Yes
Submarket-Year FE	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are robust. Only includes properties from REIS (covering market-rate multifamily with more than 20 units in the 50 largest cities classified by REIS). Local Vacancy Differential & Local Rent Mis-Pricing are the residuals taken from regressions of vacancy rate and log asking rent per square foot on year-by-submarket fixed effects, along with controls for log number of units, floors, buildings, square feet per unit, and 22 different property and unit amenities with a balanced panel of properties within the same geographic submarket.

E Appendix: CBSA Exposure Regressions: Dynamic Effects and Asking Rent Effects

Here I replicate the specifications from Section 6 using additional time periods and rent indices.

We learn a few additional lessons from these regressions. Table E8 shows the analogous results using data from 47 CBSAs in REIS asking rent microdata (covering 2005-2019). In columns 1 and 2, the share of mortgages prepaying is negatively correlated with rent growth, but once we control for local economic conditions or year and city fixed effects, we observe that the share of mortgages prepaying has a positive relationship with local asking rents. This asking rent-share prepaying relationship is different in direction and magnitude from the regressions using Census. However, the direction and significance of the interaction terms between share prepaying and mortgage rate exposure are the same—there is a positive relationship between rate exposure and rent growth for cities with a higher share of multifamily mortgages prepaying. The magnitude of the interaction coefficients is somewhat larger in the REIS regressions than in the Census regressions, which may be due to the fact that asking rents (particularly on higher-quality, market-rate buildings) can be more volatile than the distribution of existing rents overall.

Table E7: Dynamics of Aggregate Rent Effect: CBSA Exposure to Interest Rates and Prepayment and Maturity

	t-1	t	t+1	t+2	t+3
Share of Mortgages Prepay/Matured	-0.069	0.291	1.580	4.058	4.997
	(2.986)	(5.103)	(5.285)	(2.686)	(4.245)
Share X Rate Exposure (Mkt Rate - Act Rates)	2.779	3.774	6.179***	6.783**	4.017
	(1.803)	(2.483)	(1.021)	(2.510)	(4.509)
Share Renovated	0.693***	1.097**	1.015*	1.562**	1.468**
	(0.186)	(0.413)	(0.473)	(0.474)	(0.487)
Employment Growth	0.014	0.111	0.274**	0.419***	0.517***
	(0.036)	(0.067)	(0.088)	(0.093)	(0.114)
Income Growth	0.117*	0.214**	0.253**	0.269**	0.377***
	(0.057)	(0.092)	(0.103)	(0.092)	(0.098)
Obs.	1860	1705	1550	1395	1240
Year FE	Yes	Yes	Yes	Yes	Yes
CBSA FE	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are clustered by CBSA. Each column uses a different outcome for rent growth from $t-1$ through $t+3$.

Table E8: REIS Asking Rents: CBSA Exposure to Interest Rates and Prepayment and Maturity

	OLS			TWFE		
Share of Mortgages Paid Off	2.239	10.200	2.450	6.680	24.739**	18.420***
	(9.107)	(10.615)	(5.895)	(6.077)	(10.532)	(4.227)
Share X Rate Exposure (Mkt Rate - Act Rates)		32.565***	14.833***		35.302***	21.614***
		(6.780)	(4.712)		(9.236)	(4.752)
Share Renovated			1.542*			0.011
			(0.905)			(1.283)
Employment Growth			0.712***			0.778***
			(0.064)			(0.210)
Income Growth			0.001			-0.087
			(0.156)			(0.197)
Obs.	552	552	552	552	552	552
Year FE	No	No	No	Yes	Yes	Yes
CBSA FE	No	No	No	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are clustered by CBSA.

F Appendix: More Evidence on Whether Appraisal Values Reflect Asking Rents Even Conditional on Observed Financial Outcomes

While Table 5 provides proximate evidence of the importance of asking rents, my main hypothesis about the importance of asking rents relies on landlords strategically changing asking rents around the time of a capital event (i.e. refinance or acquisition). To test this, I control for the change in asking rents over the term of the original mortgagee up to 2 years prior to prepayment or maturity. I add an additional independent variable for the change in asking rents during the final 2 years of the loan term. This is meant to test whether the change in asking rents specifically during the time period in which appraisers are supposed to analyze detailed rent rolls is particularly important in predicting their appraised values.

I report the results of the analogous regressions but including recent change in log asking rents in Table F9. The results in Columns 1-3 suggest that recent asking rents are similarly important to the change in asking rents over the term of the mortgage from Table 5, Columns 5-8. However, in Table F9 Column 4, I show that adding in the recent change in asking rents implies that both the asking rents over the earlier part of the term and the most recent two years have explanatory power in looking at variation in appraisal values. In Columns 5-8, I show that the change in early and recent asking rents both have independent significant relationships with appraisal values even condition on revenues, expenses, and DSCRs.

Table F9: Trepp-REIS Merge: Sensitivity of Appraisal Values to Most Recent 2 Years of Asking Rents

	Change Log Appraisal Value							
Change Log Revenue	1.238***				1.118***			1.572***
	(0.064)				(0.055)			(0.063)
Change Log Expenses		0.477***				0.333**		-0.629***
		(0.109)				(0.132)		(0.056)
Change DSCR			-0.012***				-0.008***	-0.003
			(0.002)				(0.002)	(0.003)
Change Log Asking Rent (up to 2 yrs prior)				1.001***	0.348***	0.912***	0.997***	0.249***
				(0.070)	(0.062)	(0.077)	(0.070)	(0.057)
Recent Change Log Asking Rent	0.117**	0.335***	0.353***	0.723***	0.267***	0.681***	0.725***	0.163***
	(0.049)	(0.082)	(0.083)	(0.083)	(0.056)	(0.082)	(0.082)	(0.048)
Change Market Rates	0.016	-0.016	-0.066***	-0.017	0.024**	0.012	-0.019	-0.014*
	(0.011)	(0.019)	(0.018)	(0.014)	(0.010)	(0.016)	(0.014)	(0.009)
Renovation in Prior 3 Years	0.027*	0.040	0.038	0.033	0.026*	0.034	0.032	0.020
	(0.016)	(0.025)	(0.026)	(0.022)	(0.016)	(0.022)	(0.022)	(0.013)
Any Renovation Since Prior Origination	-0.020	-0.001	0.012	-0.025	-0.030**	-0.029	-0.023	-0.023*
	(0.015)	(0.023)	(0.024)	(0.020)	(0.015)	(0.020)	(0.020)	(0.012)
R^2	0.72	0.30	0.23	0.42	0.74	0.45	0.42	0.81
Obs.	627	627	627	624	624	624	624	624

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are robust.

This evidence provides support for the contention that appraisers and underwriters consider asking rents when valuing multifamily properties, but does not speak to whether this outcome is a desirable part of the valuation process. In the next table, I provide one test of whether the use of changes in asking rents is a useful predictor of ex post property-level outcomes (independent of historical changes in other property-level financials). As an outcome variable, I use a measure of "ex post income growth". I take net operating income, not considering mortgage payments or capital reserves, from one year prior to the original mortgage prepayment year to 2 years into the new mortgage's term. This is a limited ex post outcome because I am constrained by the time period—many mortgages with repeated appraisal observations and history of asking rent are from the late 2010s (asking rent data ends in 2019 and the net income data from Trepp ends in 2020). This outcome variable reduces the sample size to 438 properties.

In Table F10, I present the results of these regressions. I conclude two things from this table. First, individually, the change in revenues over the term of the original loan is strongly negatively related to ex post net income growth (suggesting a potential negative autocorrelation in NOI). Second, recent asking rent growth has some predictive power for ex post net income growth. It appears that recent asking rent growth can be an indication that higher recent rent rolls will effect net income growth over the next two years. Again, this is not dispositive that asking rents are not useful indicators of property value, but it does provide complementary evidence to that presented in Section 5 on how property outcomes and landlord behavior change in response to financing cost shocks.

Table F10: Trepp-REIS Merge: Prediction of Ex Post NOI Growth to Most Recent 2 Years of Asking Rents

	Ex Post NOI Growth (from t to t+2 into New Mortgage)							
Change Log Revenue	-0.146***				-0.183***			-0.274***
	(0.055)				(0.062)			(0.090)
Change Log Expenses		-0.054				-0.059		0.120
		(0.059)				(0.059)		(0.085)
Change DSCR			-0.002				-0.002	-0.000
			(0.015)				(0.016)	(0.016)
Change Log Asking Rent (up to 2 yrs prior)				0.019	0.127	0.035	0.020	0.148*
				(0.077)	(0.083)	(0.079)	(0.078)	(0.085)
Recent Change Log Asking Rent	0.260***	0.241***	0.242***	0.251**	0.320***	0.257**	0.252**	0.341***
	(0.091)	(0.092)	(0.093)	(0.105)	(0.106)	(0.105)	(0.106)	(0.109)
Change Market Rates	-0.010	-0.006	-0.000	0.001	-0.006	-0.005	0.001	0.002
	(0.017)	(0.018)	(0.017)	(0.016)	(0.017)	(0.018)	(0.017)	(0.019)
Renovation in Prior 3 Years	0.055**	0.053**	0.053**	0.053**	0.055**	0.054**	0.053**	0.055**
	(0.026)	(0.026)	(0.027)	(0.027)	(0.026)	(0.026)	(0.027)	(0.027)
Any Renovation Since Prior Origination	-0.025	-0.027	-0.028	-0.028	-0.028	-0.028	-0.028	-0.029
	(0.024)	(0.024)	(0.024)	(0.025)	(0.025)	(0.024)	(0.025)	(0.025)
R^2	0.13	0.12	0.12	0.12	0.14	0.12	0.12	0.14
Obs.	440	440	440	438	438	438	438	438

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are robust.

Finally, I look at the implications of the focus on asking rents for property-specific mortgage outcomes, starting with actual mortgage rates. Lenders may credit ration through prices—in this case mortgage rates. We would expect that net incomes and cash flows would affect mortgage rates. It is unclear why asking rents would affect rates conditional on net incomes and cash flows, unless appraisers or underwriters were over-emphasizing the importance of asking rents in projecting future income or property value.

I use the analogous within-property regression design, controlling for the year of origination of the new mortgage and an index of the change in mortgage rates from the quarter of original origination and the quarter the prior loan is prepaid or matures. Lenders explicitly price based on debt service coverage ratios, so we should expect net cash flows to have a strong relationship with mortgage rates.

In Table F11, we can see the expected relationships between actual changes in mortgage rates and market rates—a one percentage point change in market rates translates to a nearly one percentage point change in mortgage rates. Revenues and expenses have a offsetting relationships with rates, and change in securitized DSCR is weakly negatively correlated with the change in rates.

The main result of interest here is the relationship between mortgage rates and change in asking rents. It appears that conditional on the property's financial outcomes, properties with higher growth in asking rents are able to finance at lower mortgage rates. The scale of the coefficients suggests that 10% higher asking rent growth is related to 6.7 basis points lower mortgage rates.

I test the asking rent-LTV relationship in Table F12. Net incomes are strongly positively related to loan-to-value ratios conditional on DSCR. Including both change in revenues and change in expenses returns coefficients in opposite directions, which suggests that movements in expenses and revenues move leverage choices in opposite directions. Asking rents have a negative relationship with LTV. I hesitate to interpret this relationship given the endogenous connections between these variables. The negative relationship makes sense to the extent that asking rent growth may both increase appraisal values and decrease property-specific mortgage rate offerings ceteris paribus—lowering the price of credit could induce a relative increase in demand for credit (higher loan size). Table F13 shows the size and significance of this asking rent-loan size relationship. Ten percent higher asking rents correspond to 5.6-6.3% higher loan sizes, but once conditioned on the change in revenues, that coefficient is reduced to near zero and not statistically significant.

Table F11: Trepp-REIS Merge: Relationship Between Change in Mortgage Rates and Asking Rents

	Change Actual Mortgage Rate							
Change Log Revenue	0.177				0.359			1.276***
	(0.219)				(0.226)			(0.372)
Change Log Expenses		-0.516**				-0.487**		-1.279***
		(0.215)				(0.221)		(0.307)
Change DSCR			-0.019				-0.019	-0.017
			(0.033)				(0.033)	(0.033)
Change Log Asking Rent				-0.276	-0.461	-0.173	-0.280	-0.669**
				(0.266)	(0.282)	(0.274)	(0.266)	(0.282)
Change Market Rates	1.017***	0.954***	1.001***	0.991***	1.005***	0.948***	0.987***	0.924***
	(0.066)	(0.067)	(0.063)	(0.063)	(0.065)	(0.067)	(0.064)	(0.065)
Renovation in Prior 3 Years	-0.156	-0.154	-0.155	-0.147	-0.148	-0.150	-0.149	-0.161
	(0.108)	(0.108)	(0.108)	(0.109)	(0.109)	(0.109)	(0.109)	(0.107)
Any Renovation Since Prior Origination	-0.023	-0.007	-0.015	-0.012	-0.015	-0.004	-0.008	0.002
	(0.099)	(0.099)	(0.100)	(0.100)	(0.100)	(0.099)	(0.100)	(0.098)
R^2	0.44	0.45	0.44	0.44	0.44	0.45	0.44	0.46
Obs.	627	627	627	627	627	627	627	627

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are robust.

Table F12: Trepp-REIS Merge: Relationship Between Change in Leverage and Asking Rents

	Change Securitized LTV							
Change Log Revenue	4.224*				6.656**			17.236***
	(2.404)				(3.005)			(3.864)
Change Log Expenses		-4.823*				-4.529		-15.551***
		(2.777)				(2.883)		(3.579)
Change DSCR			-1.331				-1.337	-1.305
			(0.897)				(0.894)	(0.900)
Change Log Asking Rent				-2.717	-6.151*	-1.766	-3.007	-8.625***
				(3.000)	(3.511)	(3.126)	(2.928)	(3.312)
Change Market Rates	0.652	-0.102	0.088	0.235	0.495	-0.164	-0.068	-0.757
	(0.628)	(0.685)	(0.608)	(0.604)	(0.621)	(0.673)	(0.600)	(0.650)
Renovation in Prior 3 Years	0.874	0.931	0.810	1.000	0.979	0.972	0.879	0.733
	(1.171)	(1.167)	(1.078)	(1.162)	(1.159)	(1.160)	(1.071)	(1.060)
Any Renovation Since Prior Origination	-0.959	-0.761	-0.609	-0.802	-0.861	-0.725	-0.535	-0.430
	(1.108)	(1.110)	(1.018)	(1.105)	(1.101)	(1.107)	(1.013)	(0.995)
R^2	0.03	0.03	0.06	0.02	0.03	0.03	0.07	0.11
Obs.	627	627	627	627	627	627	627	627

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are robust.

Table F13: Trepp-REIS Merge: Relationship Between Change in Origination Loan Size and Asking Rents

	Change Log Loan Balance at Origination							
Change Log Revenue	1.102***				1.074***			1.478***
	(0.127)				(0.150)			(0.169)
Change Log Expenses		0.425**				0.331*		-0.590***
		(0.183)				(0.200)		(0.161)
Change DSCR			-0.056***				-0.055***	-0.049***
			(0.007)				(0.006)	(0.006)
Change Log Asking Rent				0.631***	0.070	0.561***	0.621***	-0.025
				(0.164)	(0.184)	(0.172)	(0.163)	(0.182)
Change Market Rates	0.193***	0.162***	0.108***	0.152***	0.194***	0.182***	0.140***	0.147***
	(0.040)	(0.045)	(0.041)	(0.041)	(0.040)	(0.044)	(0.041)	(0.042)
Renovation in Prior 3 Years	0.026	0.043	0.038	0.028	0.025	0.030	0.023	0.016
	(0.064)	(0.065)	(0.064)	(0.066)	(0.065)	(0.066)	(0.065)	(0.063)
Any Renovation Since Prior Origination	-0.016	-0.002	0.018	-0.008	-0.017	-0.014	0.003	-0.001
	(0.062)	(0.063)	(0.062)	(0.063)	(0.062)	(0.064)	(0.063)	(0.061)
R^2	0.18	0.12	0.13	0.13	0.18	0.14	0.14	0.21
Obs.	623	623	623	623	623	623	623	623

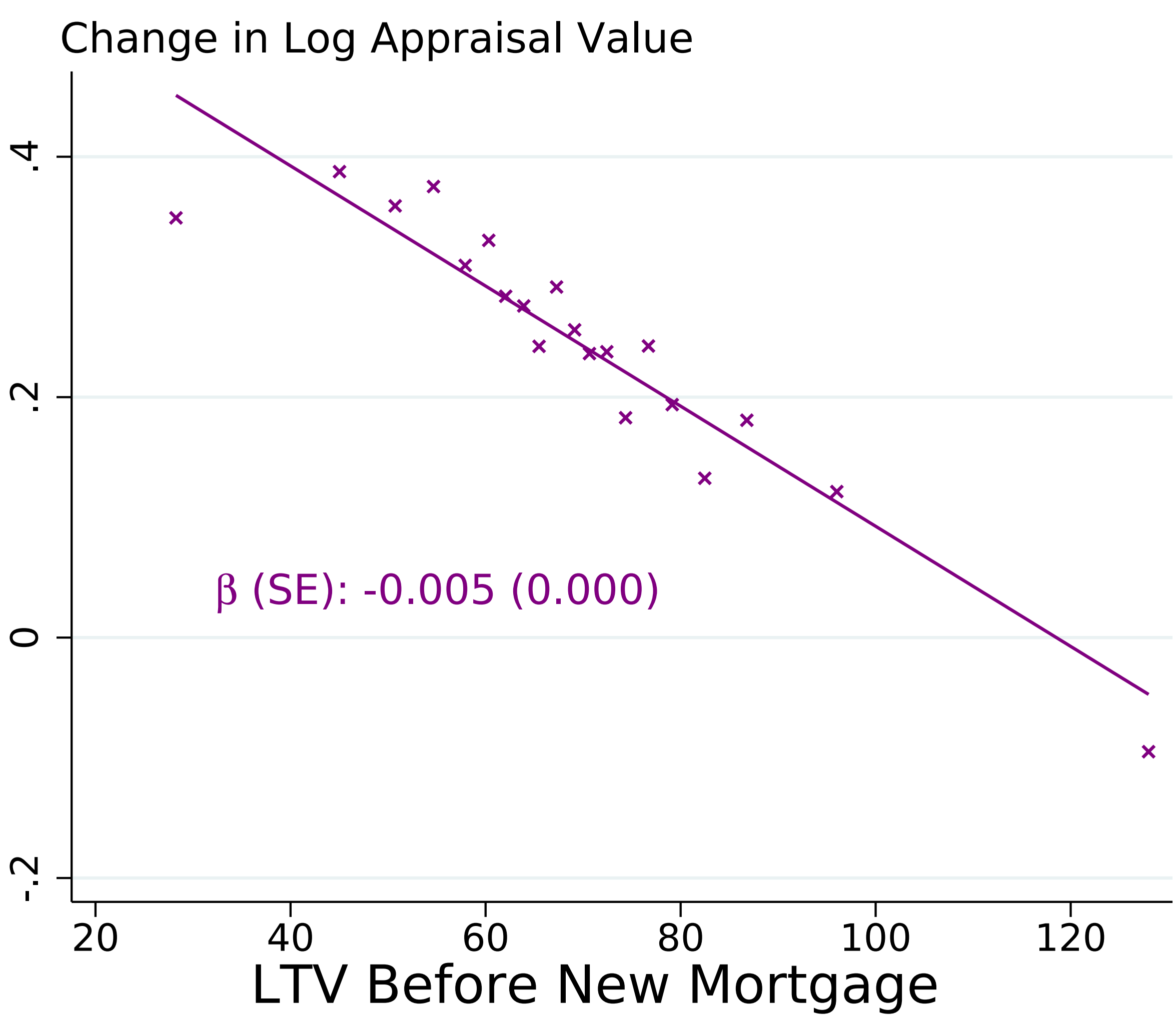
Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are robust.

G Appendix: Landlords' Leverage, Cap Rates, & Cash-Out at Refinancing or Sale

In this section, I provide complementary evidence to the main regressions. I validate the mark-to-market LTV measure used in the regressions. I measure the amount of landlords' cash-out (or cash-in) amount, and show its relationship with pre-refinance LTV and mortgage rate exposure. Finally, I show the within-property cap rate change and its relationship with property-specific leverage and rate exposure.

First, I show that the mark-to-market LTV is meaningful. The LTV is measured two years prior to refinance and uses the actual loan balance and a measure of property value change based on the FHFA single-family house price index. The Figure shows that the FHFA house price index (which drives most of the change in LTV) is strongly correlated with changes in appraised values. As values decline, LTVs rise. This generates a strong negative correlation between existing LTV and appraisal at refinance. Next, I discuss the calculation of actual cash-out amounts and correlation with LTV and rates.

Figure G12: Mark-to-Market LTV Before Refinance and Actual Change in Appraised Value

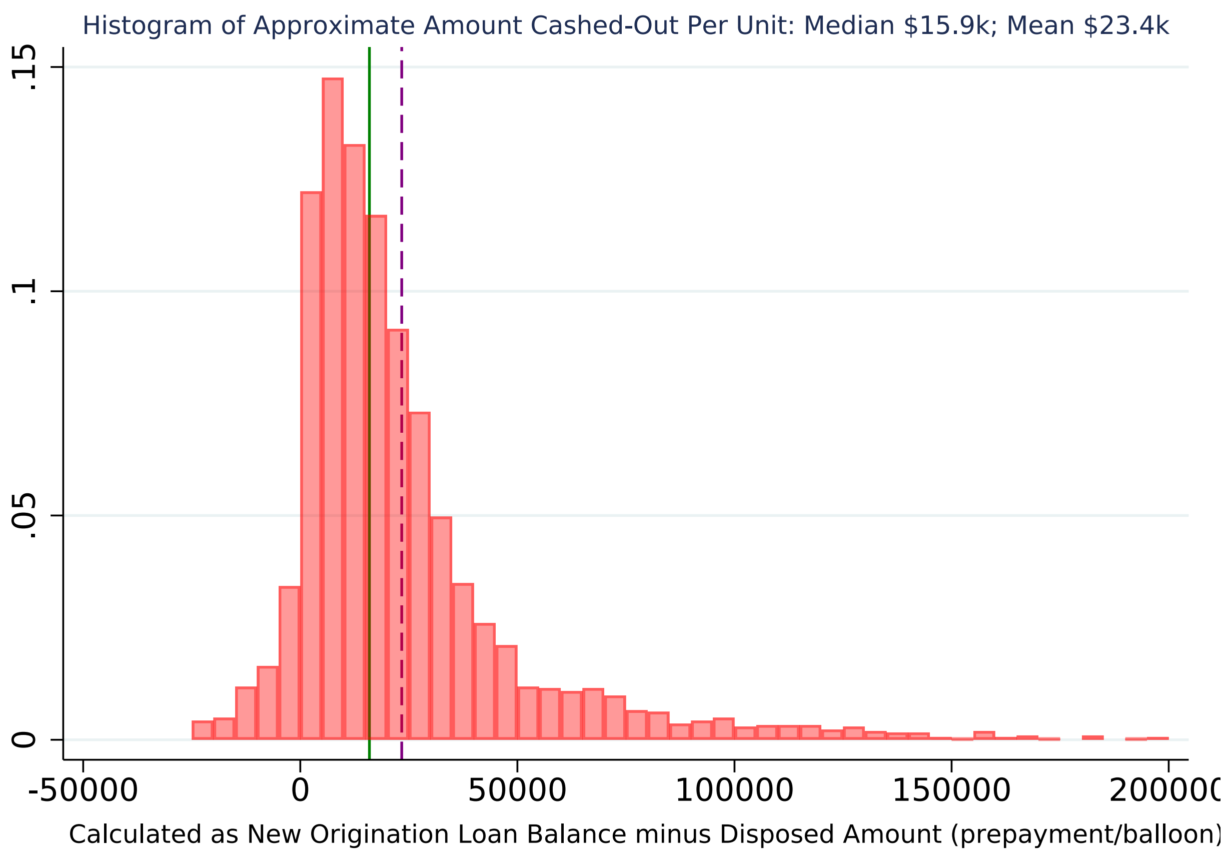


In my matched sequential subsample of properties from Trepp, I construct a measure of the change in equity to quantify how much landlords extract from each property at a credit event (refinance or sale). To do this, I use the disposed amount from the prior loan (either the amount prepaid or the balloon payment at loan maturity), and the origination loan balance of the new mortgage. I can also take back of the envelope estimates of the cost of paying or prepaying the original loan and originating the new loan (common industry estimates account for 2-5% of loan balance for closing costs).

In Figure G13, I show a histogram of the amount cashed out per unit. I find that the average multifamily landlord cashes out $23 thousand per unit, which translates to $4.7 million for a 200 unit property.

To given a sense of their actual return, we can net out between $0 and $500 per unit in prepayment penalties and fees, and for 200-unit property taking out a $14 million mortgage, they would pay $1,500-3,500 in closing costs. This gives us a range of average equity returns between $21 and $19 thousand per unit (or $3.8-4.2 million for a 200 unit property).

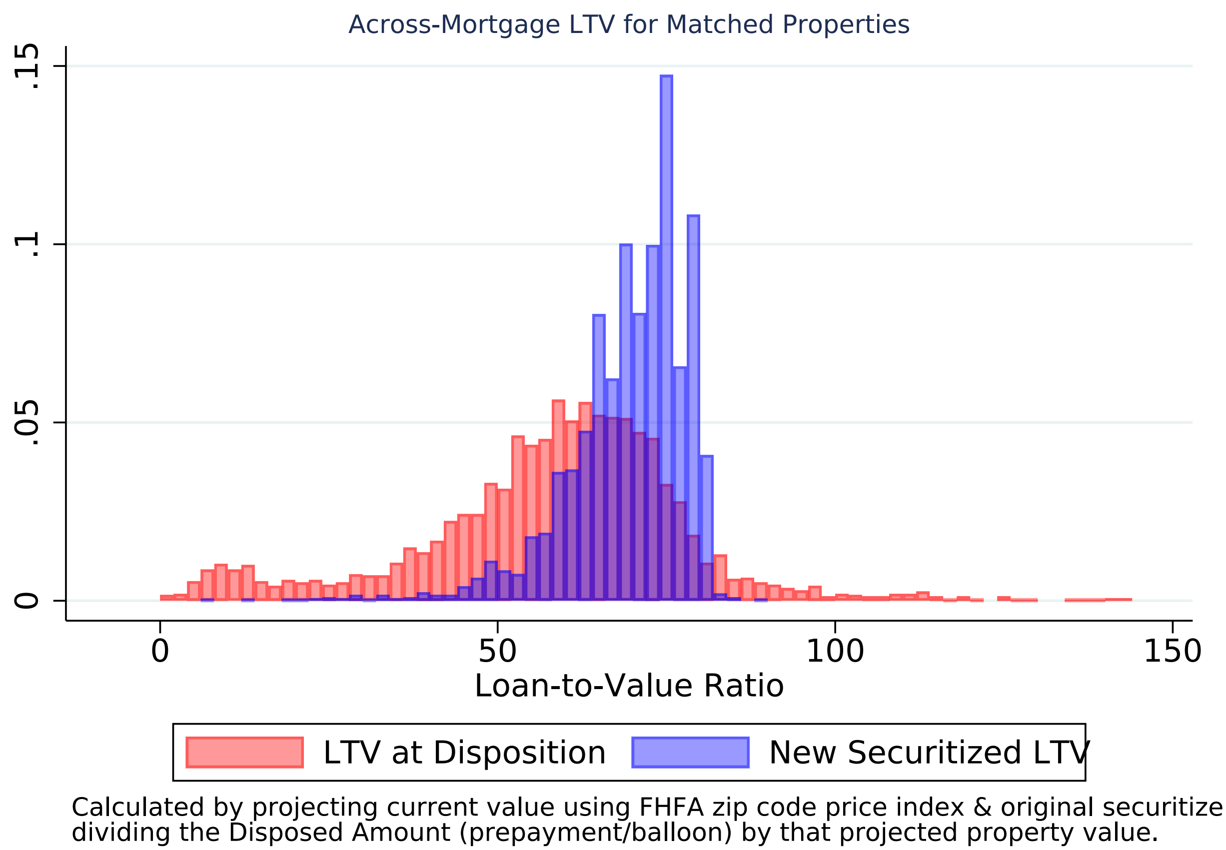
Figure G13: Histogram of Change in Property Equity (Net Cash-Out Amonut)



To show the background for the resulting ability to extract equity, I construct the LTV just prior to prepayment/maturity of the original mortgage and the securitized LTV of the newly originated mortgage. The prior LTV is constructed by taking the appraised value on the original mortgage and projecting an increase in property value using the FHFA's zip code house price index to give a rough sense of the appreciation in the property's value.

Figure G14 displays in red the relatively smooth distribution of LTV prior to a new mortgage origination because many mortgages have built equity since their prior origination, and in most cases local property values have risen—though in the long right tail we can observe that in some locations values have fallen leading to an LTV above 90-100%. In blue, I show the distribution of securitized LTVs of the newly originated mortgages. These LTVs are bunched around the most common multifamily mortgage products (as much as 80% for the GSEs, and 75%, 70%, or 65% particularly for conduit or non-bank lenders).

Figure G14: Histogram of LTV Prior to Payment/Maturity & Securitized LTV for New Mortgage



The next two figures show the correlation between the IHS of cash out per unit and (1) existing mark-to-market LTV before refinance; (2) mortgage rate exposure at refinance. There is a strong negative correlation with LTV. Cash-outs are smaller or negative for high LTVs (where property values have declined). There is little systematic correlation between mortgage rate exposure and cash out amounts. This bivariate relationship indicates a positive slope, but in supplemental regression output with year and location fixed effects, that slope is attenuated and not distinguishable from zero.

Finally, I examine how landlords and investors value cash flows from multifamily properties using within property variation across mortgages. Cap rates are a standardized metric for valuing cash flows—with more valuable, safer buildings having lower cap rate and riskier properties trading at higher cap rates. Interest rates or mortgage rates are thought to causally shift cap rates, since cap rates incorporate risk premia or the cost of debt. There is limited evidence on within-property changes in cap rates and the cost of debt before this appendix. In the two figures below, I show the change in cap rates between mortgages (taking the net income divided by appraised value for the original mortgage and new refinance or sale mortgage). The

Figure G15: Mark-to-Market LTV Before Refinance and Actual Cash-Out

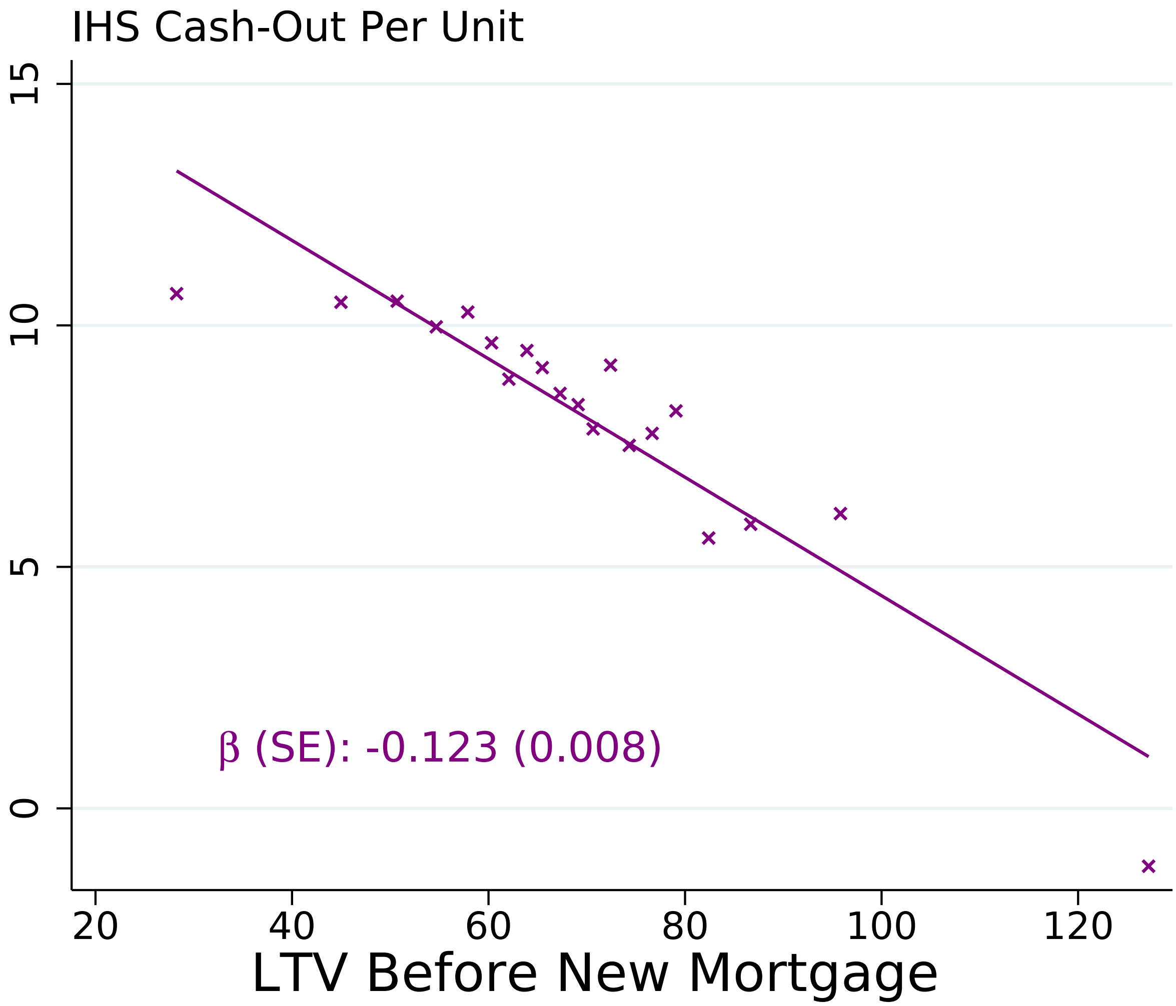
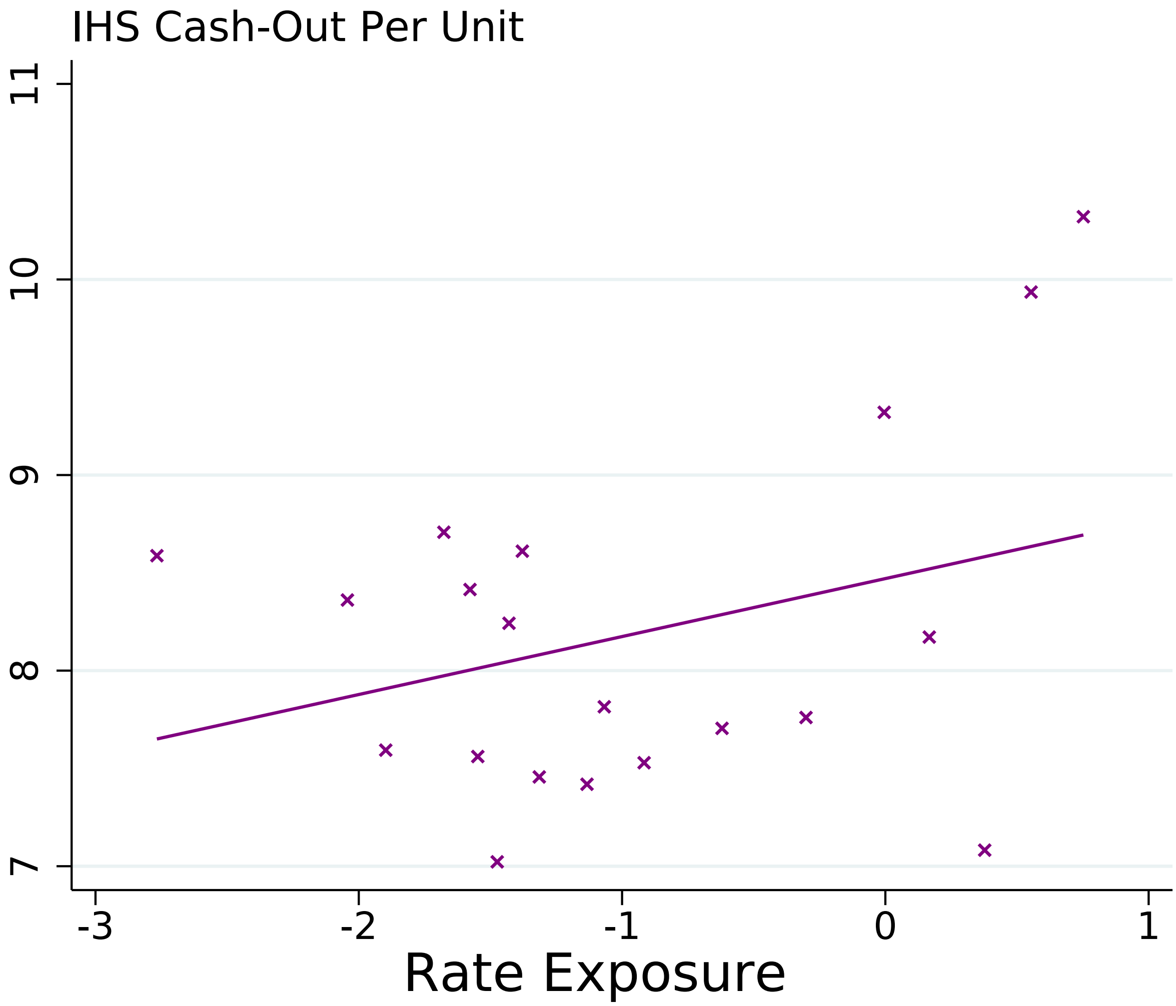


Figure G16: Rate Exposure and Actual Cash-Out



graphs show compelling evidence that leverage and cost of debt shift cap rates. Higher leverage properties appear to trade at higher cap rates. This could reflect a liquidity or risk premium for landlords selling a distressed property or a performing property with an underwater mortgage. Increases in mortgage rates appear to increase cap rates with a slope between 0.27 and 0.36. This suggests that the mortgage rate to cap rate relationship is substantial but it is significantly less than one-for-one. Glaeser et al. (2013) comment on some reasons that mortgage rate-house price elasticities are low. One potential explanation for the elasticity well-below one is that investors expect interest rates to mean-revert, and, with longer maturity debt, owners of real assets can wait to transact until financing costs are more favorable. Landlords renovation elasticity to mortgage rates is consistent with this. Landlords who rollover debt in higher rate environments appear to engage in more capital investments, which are generally done with shorter duration debt. This allows the landlord to use short term debt to improve their asset, making a bet on refinancing in a more favorable rate environment with a higher cash flow, higher equity property after completing the renovation.

Figure G17: Mark-to-Market LTV Before Refinance and Change in Cap Rate

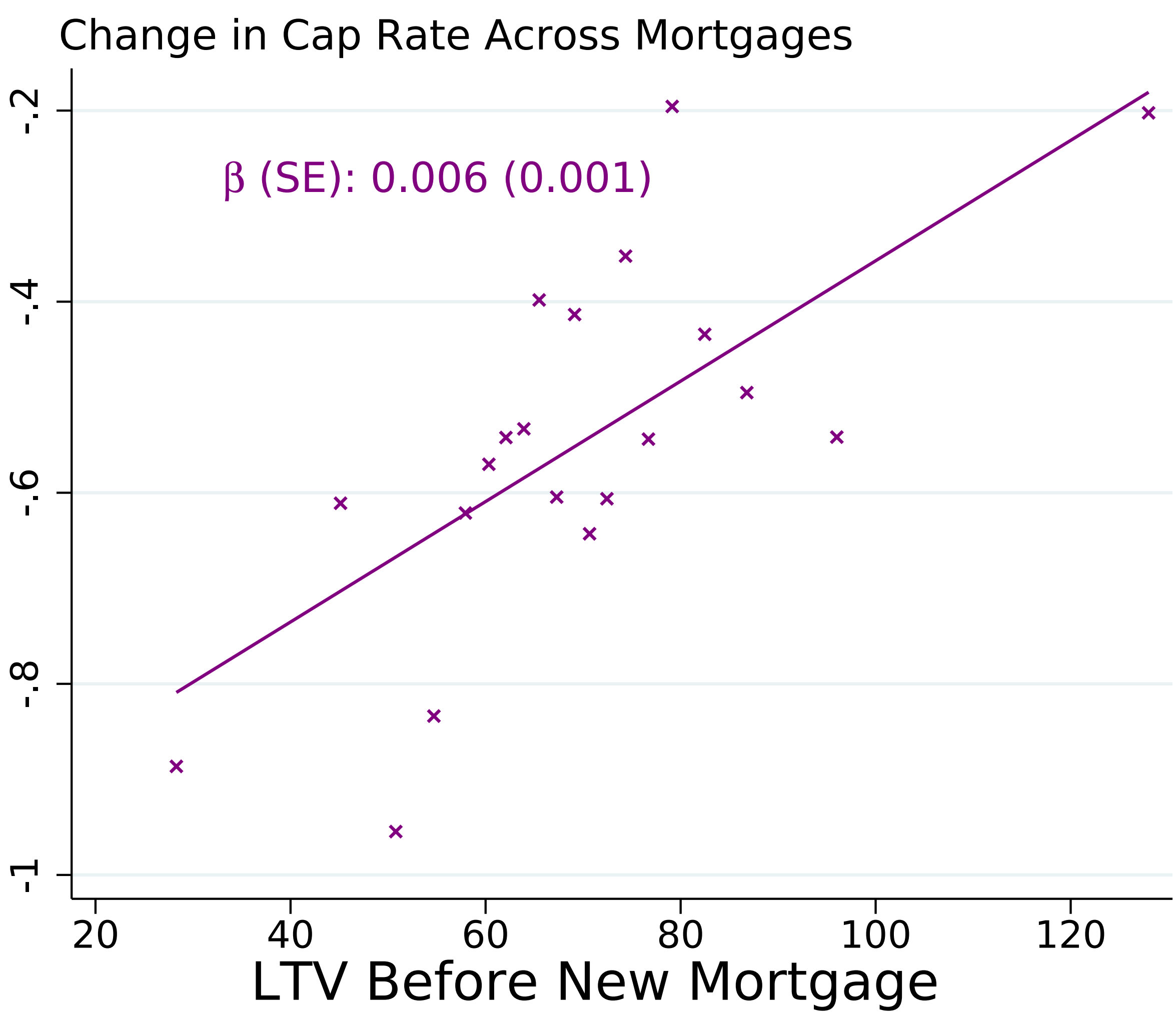
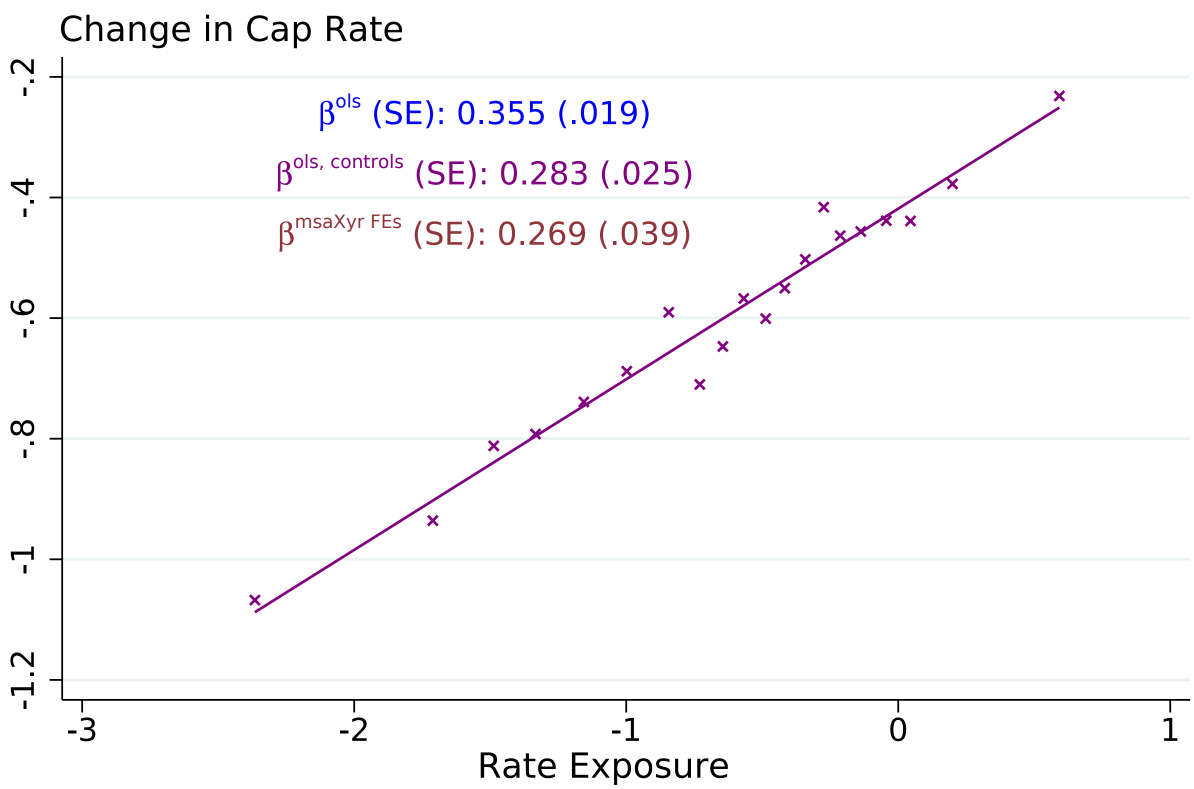


Figure G18: Rate Exposure and Change in Cap Rate



Controls for mortgage rates, house price index, and CPI-U-RS, as well as the within-property
in zip code house prices since prior origination & current LTV.