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

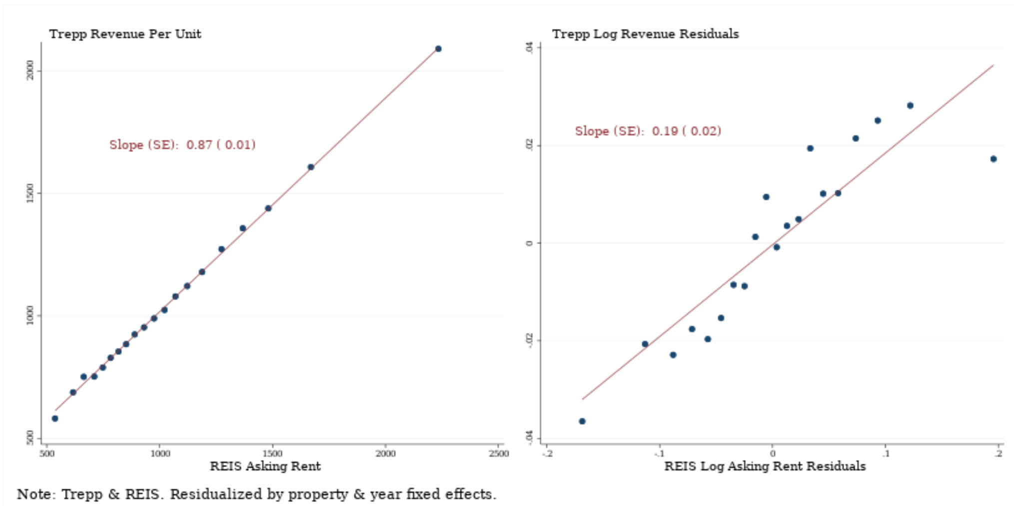
By merging Trepp and REIS data on property addresses, I can compare the levels of revenues and asking rents then show the relationship between changes in asking rents and revenues. Likewise, I can compare vacancy rates reported to servicers during the year with vacancy rates reported to REIS surveys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

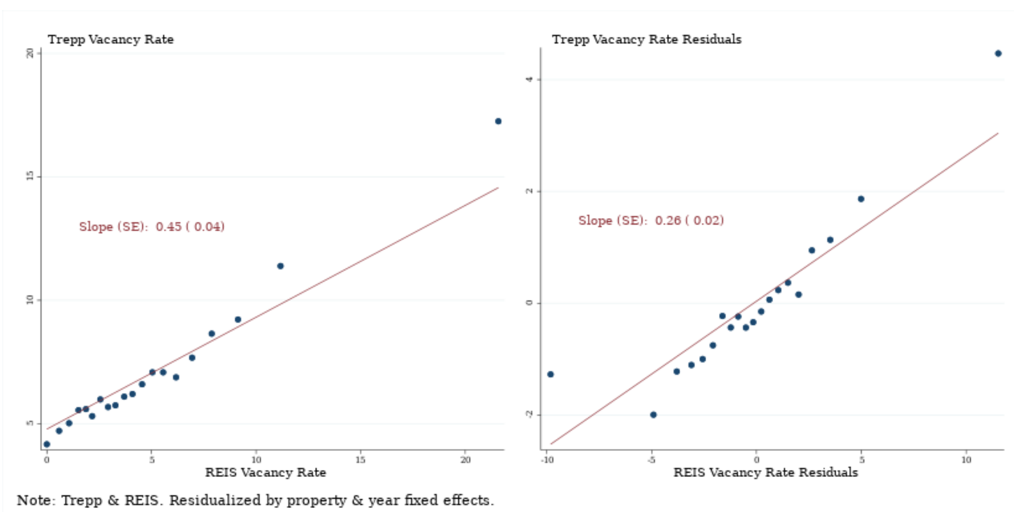
Figure A1a shows that there is a tight relationship between asking rents and average revenue per unit. On average, asking rents are higher than revenues per unit, and one dollar larger asking rents is related to 0.87 cents higher revenues–this could be due to a combination of concessions, vacancy losses,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

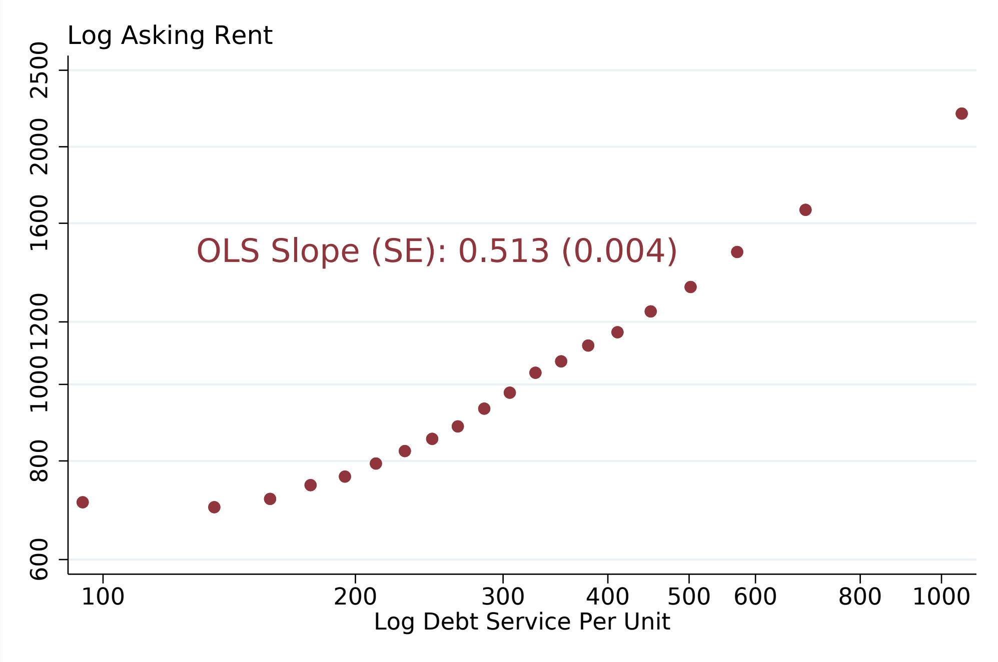
Next, Figure A2b shows the within-property relationship between debt service payments and asking rents. The graph shows a binscatter of the residual relationship, controlling for property fixed effects and year fixed effects. The slope of these relationships imply a 1 percent change in debt service payments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

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

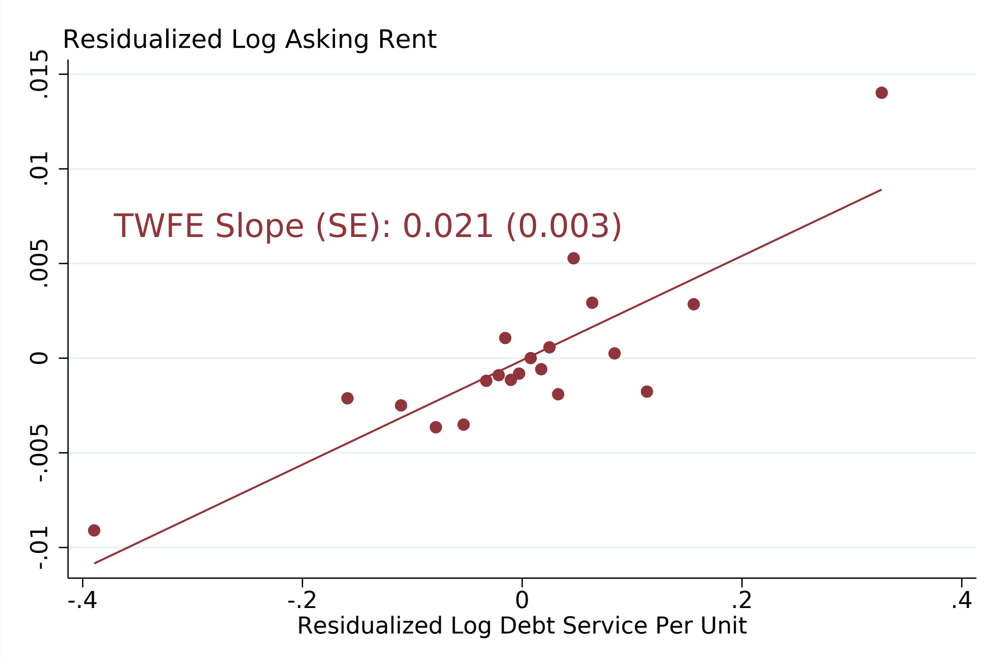
The cost of debt for single-family and multifamily residential housing have been similar over the past 25 years. Figure A3 shows that around the Fed's single-family mortgage-backed security asset purchases (QE1) in late-2008 and early-2009, a 1.06 percentage point (106 basis point) wedge opened up between 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

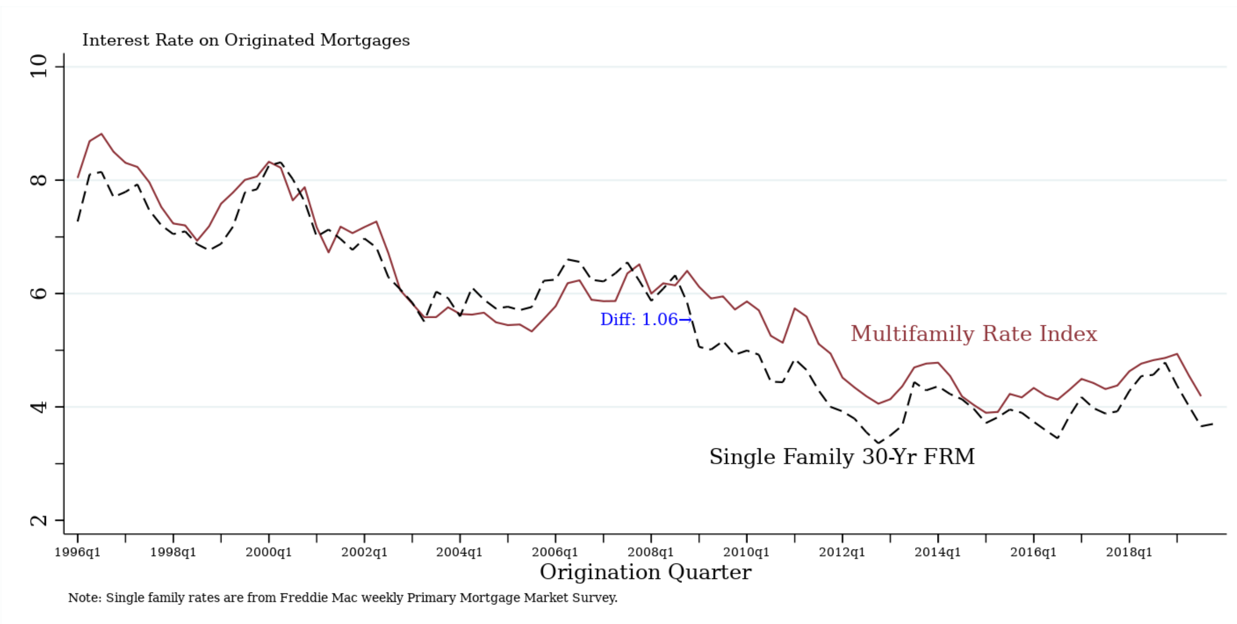


(b) Panel Relationship



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, and some ideas about improving data and industry practices in this process.

When studying landlord behavior around refinances and appraisals, we must note several institutional details about mortgages. There are potential issues surrounding the appraisal of multifamily properties that suggests that landlords have incentives to game 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 [56]. 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 most prominent that are included in appraisals are the Cost Approach, Sales Comparison Approach, and Income Approach. While exact appraiser behavior is not readily accessible, 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. 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 [57].

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. 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 tranforms 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 [58]. 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 [59].

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 suggests 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 suggests that the financial sector has 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 between the

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

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

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

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

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 [60]. 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 affects the renewal rate (and vacancy rate).

The simplest model of rental property value is that the value is the sum of discounted cash flows. However, in reality, property owners realize two types of returns—equity extraction events and annual cash flows from operations. Net returns depend on the timing of purchase (affecting the spread between capitalization rates and mortgage rates), and returns appear to affect the strategic behavior of landlords. 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 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.

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. They could (a) structure the line-item financial data in

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

a usable format, (b) collect data on asking rents, renewal rents, concessions, and credit losses (like evictions or early move-outs); and (c) make this data easily accessible to appraisers, investors, policymakers, and researchers.

C Appendix: Additional Regression & Event Study Results

To explore the subsample of merged REIS-Trepp properties that are exclusively market-rate apartments, Table C1 shows the regression results in the same form with the additional of outcomes for asking rent and free rent concessions. These properties are larger and higher quality on average. They are more likely to be professionally managed or institutionally-owned. The change in debt service payments is very similar, but the market-rate sample experiences a smaller, non-significant increase in revenues and occupied units. In this sample, the average increase in net operating incomes is $22, statistically significant at the 90% confidence level. This suggests landlords offset 24 cents of each dollar increase in debt service payments. In log terms, the elasticity of the change in debt service payments to revenues is 0.04. The smaller effect of an I-O period end on market-rate, institutionally-owned buildings is in some ways reassuring: there is less impact of a change in cash flows for buildings with more active owners or professional managers.

Table C1: End of I-O Period: REIS-Trepp Subsample Difference-in-Difference Specification

	Debt Service	Asking Rent	Occupied Units	Free Rent	Revenue	NOI	NCF
Panel A: Log and IHS Specifications							
Post X IO Loan	0.229***	-0.008	0.001	-0.096	0.008	0.057	-0.652***
	(0.011)	(0.008)	(0.011)	(0.104)	(0.011)	(0.057)	(0.211)
Obs.	5409	5612	5611	5612	5409	5409	5409
Panel B: Dollar and Level Specifications							
Post X IO Loan	90.912***	-4.160	0.629	-0.360	14.208	21.109*	-69.803***
	(5.985)	(11.186)	(1.037)	(0.327)	(16.270)	(12.287)	(12.565)
Obs.	5409	5612	5612	5612	5409	5409	5409
Property-Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are clustered by loan and year. Includes 4 years in event time; 2 years prior to reset and 2 years post reset. Relative to I-O period end year t, specification includes years: t-3, t-2, t+1, and t+2. Only includes properties merged on address between Trepp and REIS (covering market-rate multifamily with more than 20 units in the 48 largest cities classified by REIS).

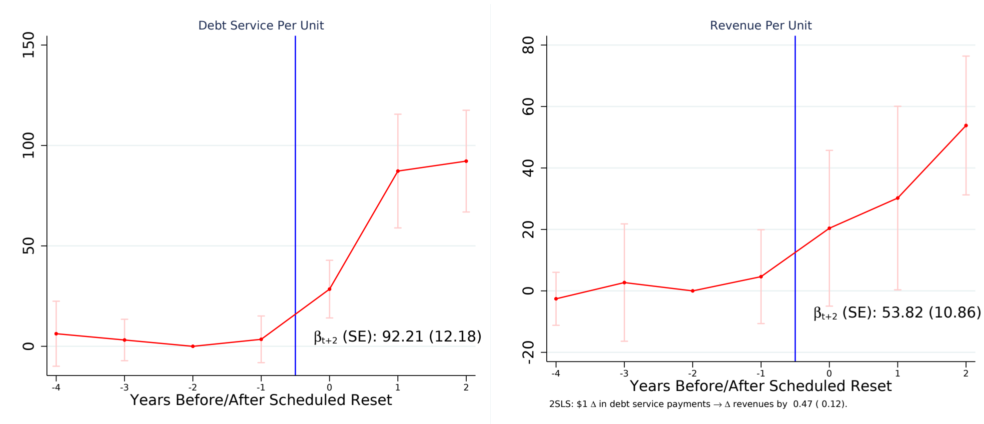
In Figure C10, I report event study regression point estimates around the year of a reported renovation, using variation both within and across mortgages.

Figure C11 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.

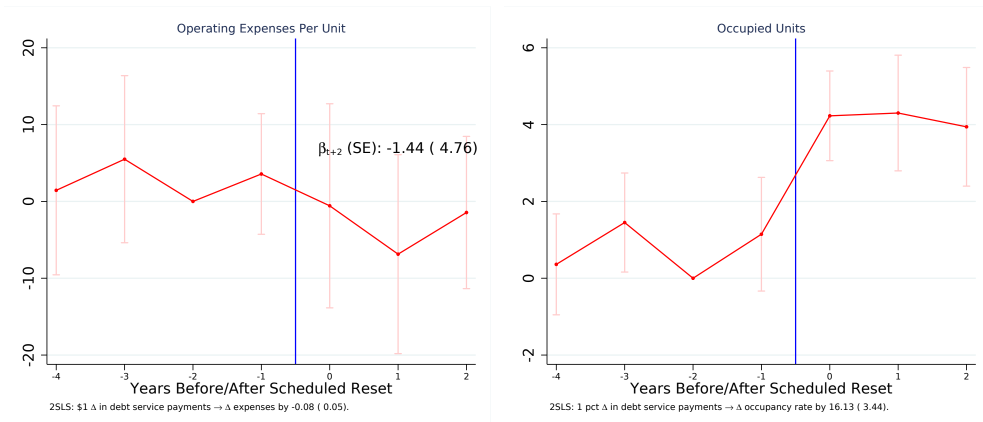
Figure C12 shows the descriptive trends for properties exposed to higher mortgage rates and properties exposed to lower mortgage rates in each of the six outcome variables for refinanced or acquired properties versus the stacked control groups. As in the descriptive trends for locked refinances above, 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

Figure C4: Event Study for I-O Mortgages in Dollar Terms

(a) Debt Service Payments & Revenues



(b) Expenses & Occupied Units



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

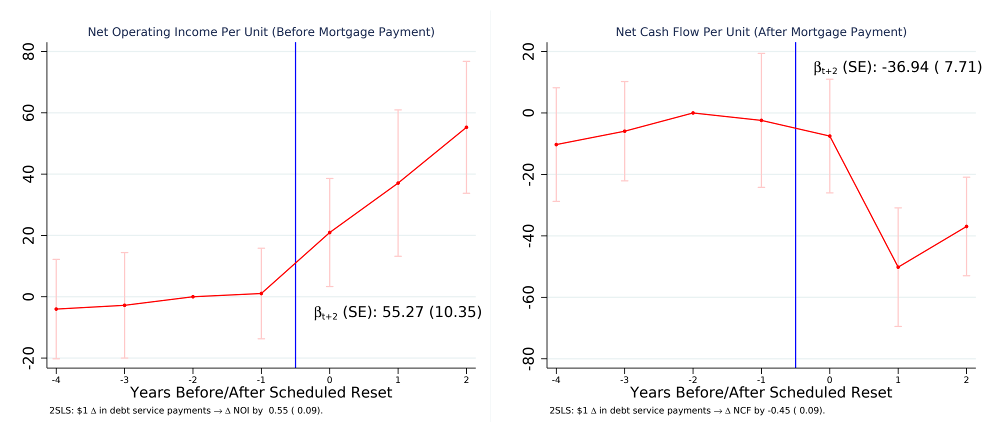
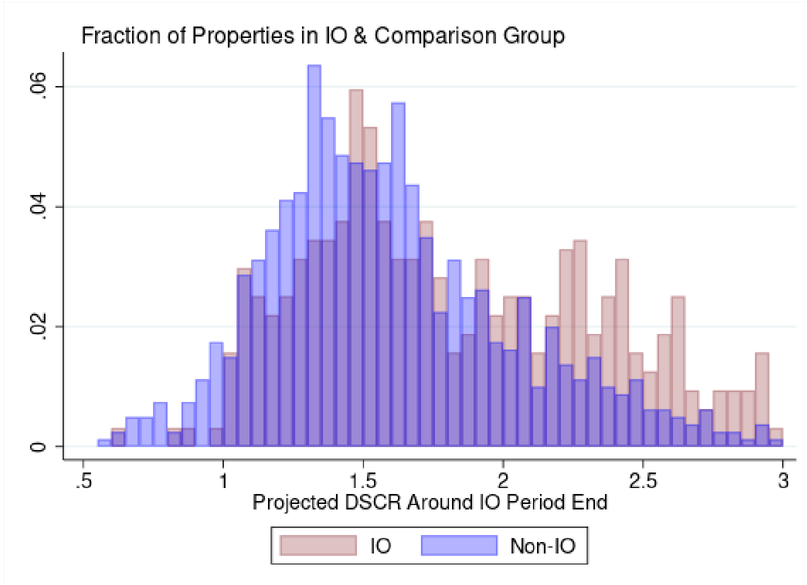


Figure C5: Histogram of I-O End by Mark-to-Market DSCR before I-O Period Ends

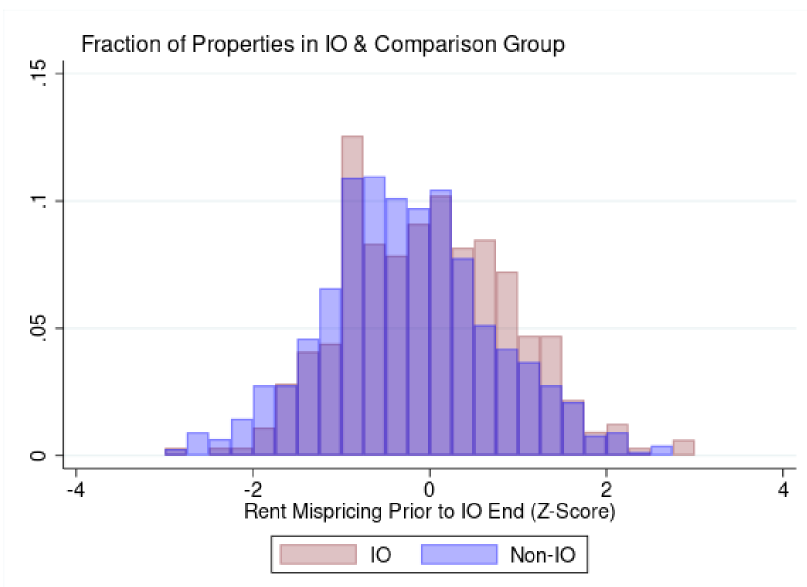
(a) DSCR Distribution for I-O and Comparison Loans Before I-O Period End



Note: This figure plots a histogram of the distribution of the DSCR 2 years before the I-O period ends with the treated I-O properties in red and control non-I-O properties in blue. DSCR is calculated as net cash flow divided by debt service payments, where net cash flow is revenue minus operating expenses and debt service payments. A DSCR of 1 means net cash flows equal debt service payments.

Figure C6: Histogram of I-O End by Mispricing Measure before I-O Period Ends

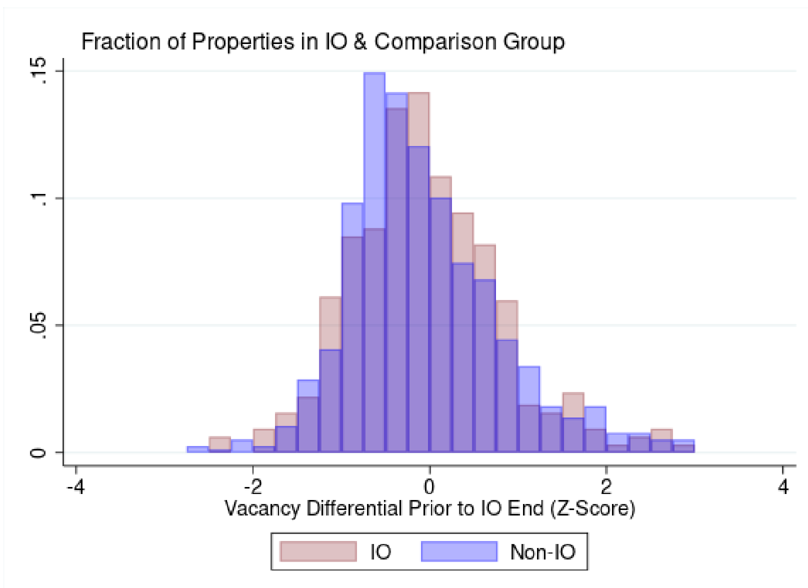
(a) Distribution of Mispricing Measure for I-O and Comparison Loans Before I-O Period End



Note: This figure plots a histogram of the distribution of the mispricing measure observed 2 years before the I-O period ends with the treated I-O properties in red and control non-I-O 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.

Figure C7: Histogram of I-O End by Vacancy Differential Measure before I-O Period Ends

(a) Distribution of Differential Vacancy Measure for I-O and Comparison Loans Before I-O Period End



Note: This figure plots a histogram of the distribution of the vacancy differential measure observed 2 years before the I-O period ends with the treated I-O properties in red and control non-I-O 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.

Table C2: 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.

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

Table C3: 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 C4: Share Prepaying and Maturing is Not Related 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.

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 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.

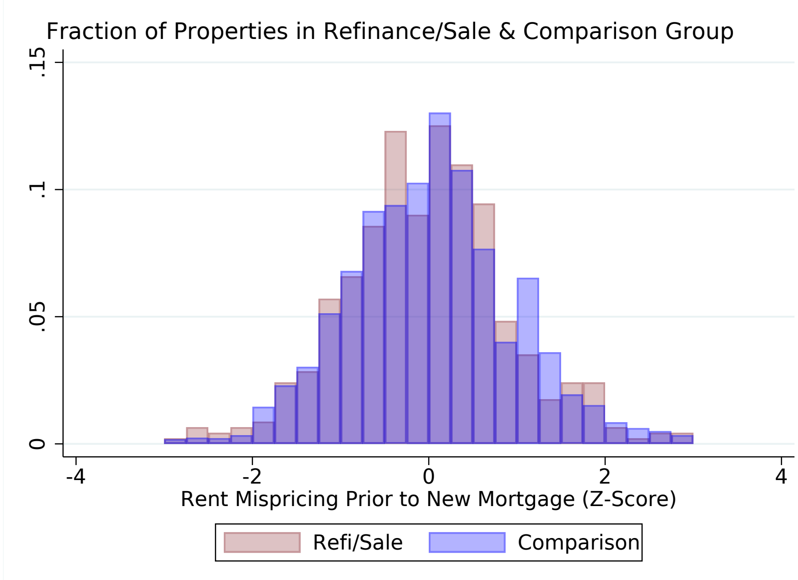
It is possible that landlords exposed to higher rates anticipate an increase in their cost of servicing debt, and increase their revenues in response. Net incomes and net cash flows increase in the two years prior to refinance for the small group of properties exposed to higher rates. Following refinance, 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 C5, as described in the section focusing on locked refinance properties. The regression results in dollars and levels is reported in Appendix Table C3. 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).[61]

[61] To understand the dynamics of the effect of an average renovation, I report in Appendix Figure C10 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

Figure C8: 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.

Panel A of Table C5 reports the difference-in-difference coefficients which are broadly consistent with the effect of a refinance on the prepayment lock properties in Table 3. 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 C3), the average renovation results 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).[62]

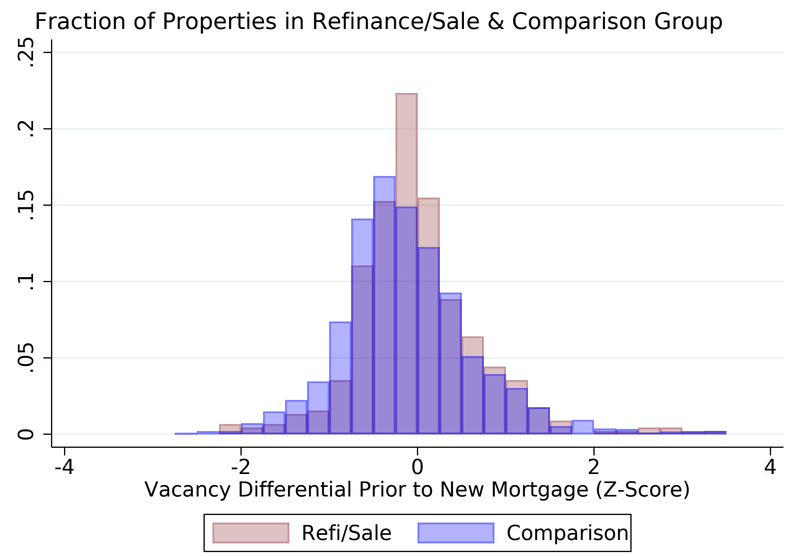
In Panel B, the coefficients on the rate exposure interaction indicate that a one percentage point change in mortgage rates causes an 8.4% change in debt service payments. A 10 percentage point increase in LTV causes a 5.9% decline in debt service payments, suggesting that landlords with higher leverage 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

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.

[62]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 C9: 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.

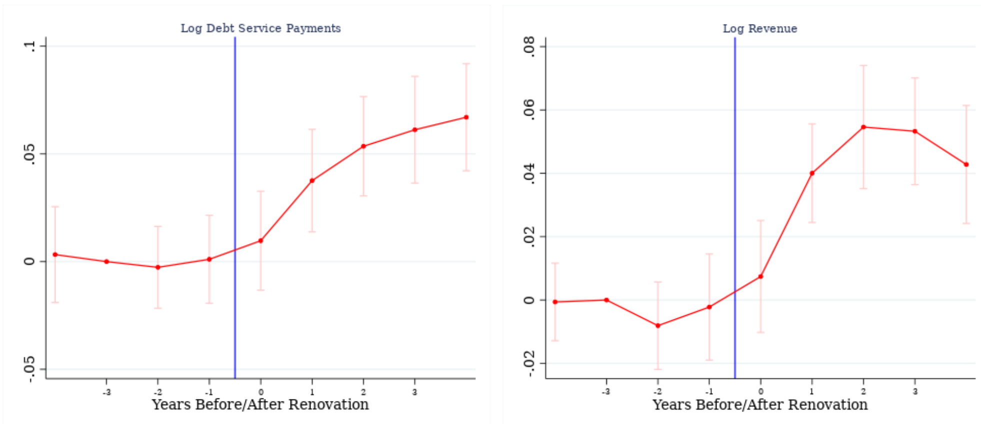
to increase revenues, but column 3 suggests that this may be related to the increase in operating expenses. In both Panel B and Panel C, landlords increase their occupancy when exposed to higher leverage, but changes in mortgage rates have no significant systematic relationship with occupancy. In dollar terms, Appendix Table C3 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 a change in landlords' risk tolerance—they may decrease rents, particularly for existing tenants to increase lease renewals.

C.1 Relationship Between Financing Costs & Renovation, Acquisition, and Default

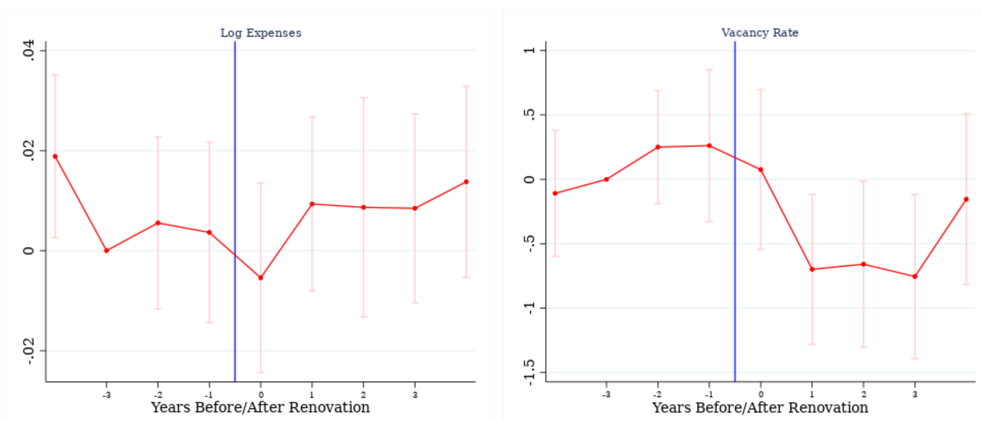
I consider now how outcomes for properties exposed to higher mortgage rates differ based on three decisions by the landlord: whether to sell the property, whether to renovate the property, and whether to default (including any instances where the lender or servicer sells or works out the loan at a loss). The 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 returns 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

Figure C10: Event Study Point Estimates Around Reported Renovations

(a) Debt Service Payments & Revenues



(b) Expenses & Occupancy Rates



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

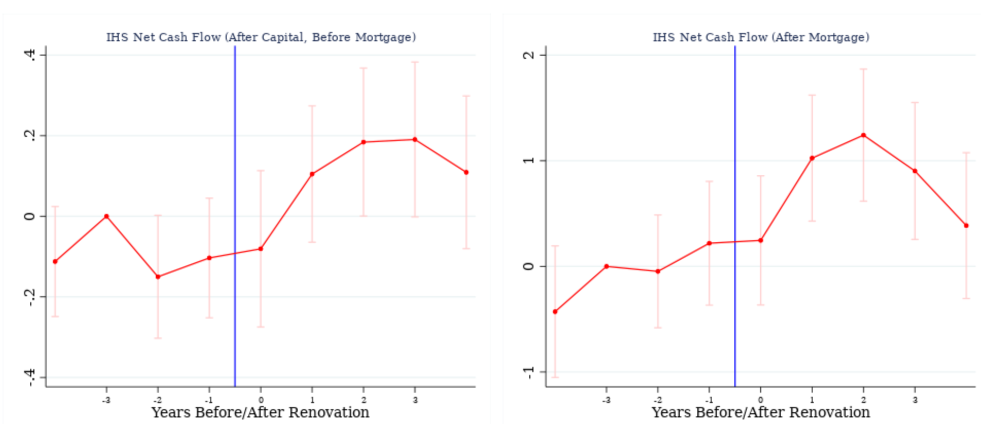
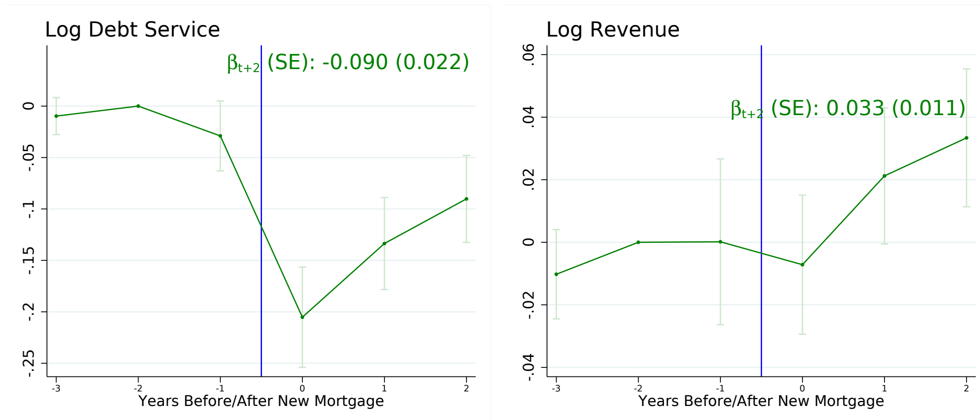
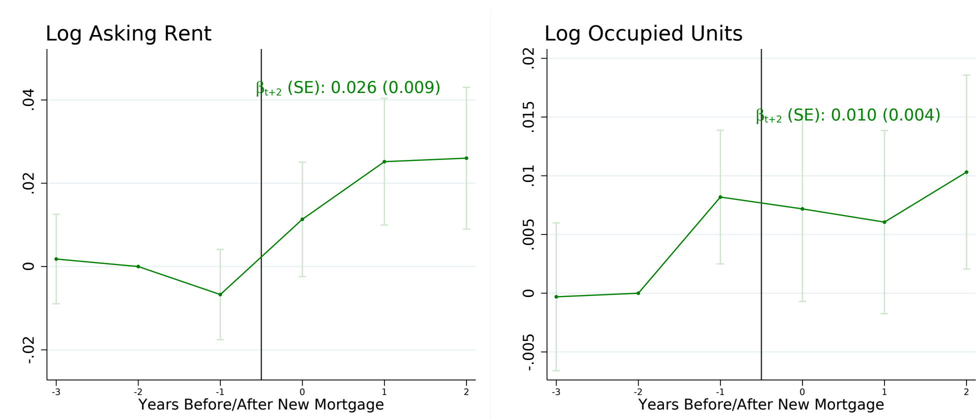


Figure C11: Landlords Change Asking Rents and Free Rent Concessions at Refinance

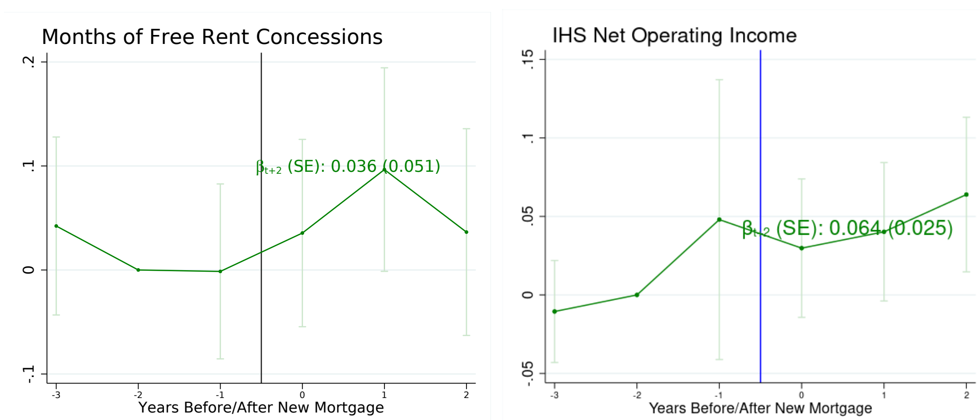
(a) Debt Service Payments & Revenues (Trepp)



(b) Asking Rent & Occupancy Rates (REIS)



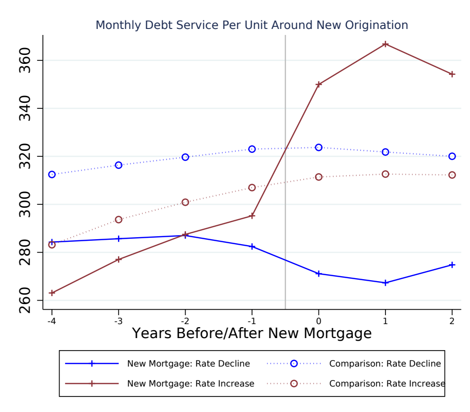
(c) Free Rent Concessions (REIS) & IHS Net Income (Trepp)



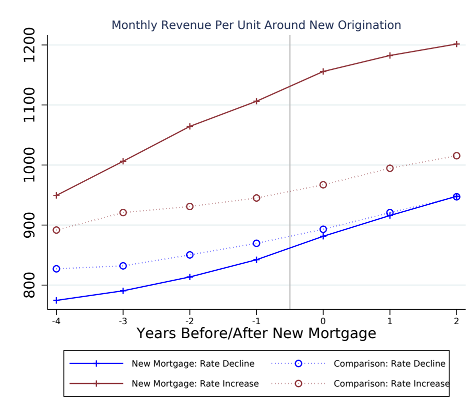
Note: These figures plot event study coefficients for financial outcomes of properties in the REIS-Trepp datasets. I compare the treated properties undergoing a refinance or sale at time 0 to the control group of non-refinanced properties using the regression equation 3.

Figure C12: Trends in Financial Outcomes for all Refinanced or Sold Properties vs Comparison Group

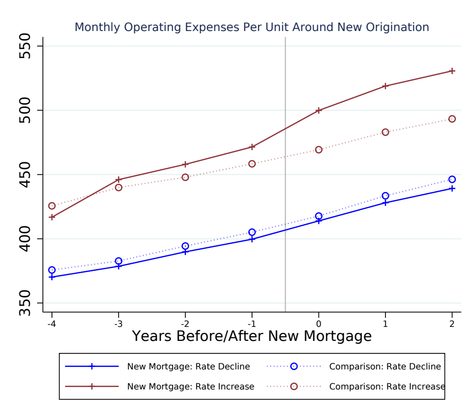
(a) Debt Service Payments



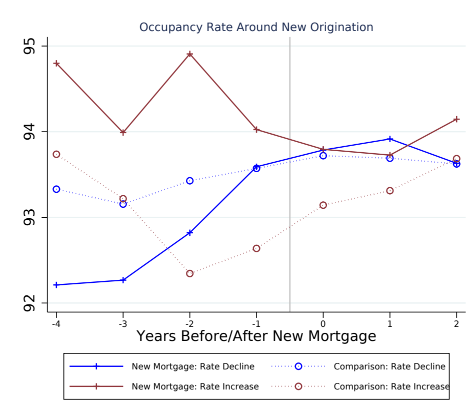
(b) Revenues



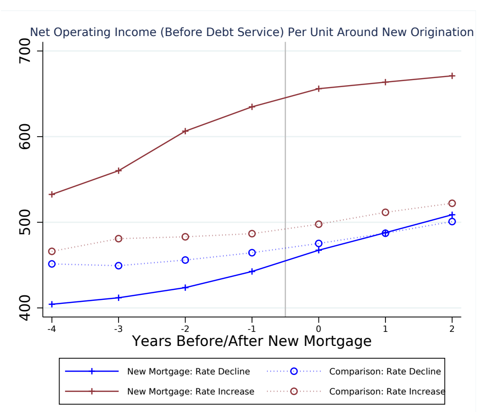
(c) Operating Expenses



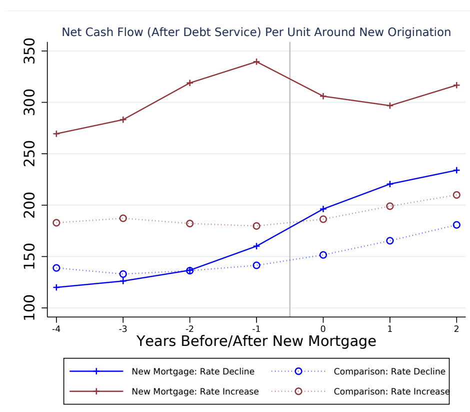
(d) Occupancy Rate



(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 C5: 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 3. Renovation is an indicator variable for whether the property was renovated in the 3 years around a refinance or sale.

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.

Table C6: 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).

In Table C6 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 the price of investing, 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 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. 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 attentuated 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 acquired, 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.

Finally, Panel C of Table C6 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.

D Appendix: Effect of Initial Rate Adjustment for ARMs

I show how landlords respond to rate resets for a set of adjustable-rate mortgages, whose first reset date is in the fourth, fifth, or sixth year of their ten year loan term (this is a limited sample since most multifamily variable-rate mortgages have resets at the beginning of the loan term). Because these rate resets occur over the course of the late 2000s and mid-2010s, generally mortgage payments fall sharply as their rates reset. Landlords may anticipate the change in the mortgage payments, but do not know far in advance in what direction or by how much their payments will change. The rate reset should be unexpected in sign and size, and affects both the cost of debt and cost of capital at the property-level.

I construct analogous stacked comparison groups to study unexpected shifts in mortgage payments around the first rate reset for adjustable-rate mortgages. The average rate reset lowered monthly per-unit mortgage payments by \$70. Net operating incomes fall around the time of the rate reset by \$20, but the decline appears to be relatively small and temporary. There is no revenue decline among liquidity-constrained loans whose DSCR is below 1.25 prior to the rate reset. On average, it seems that asking rents rise around the rate reset with little effect on vacancy rates. These ARM rate resets provide suggestive evidence of asymmetry in landlord pass-through of cost shifts.

D.1 Analyzing the First Rate Reset for ARMs

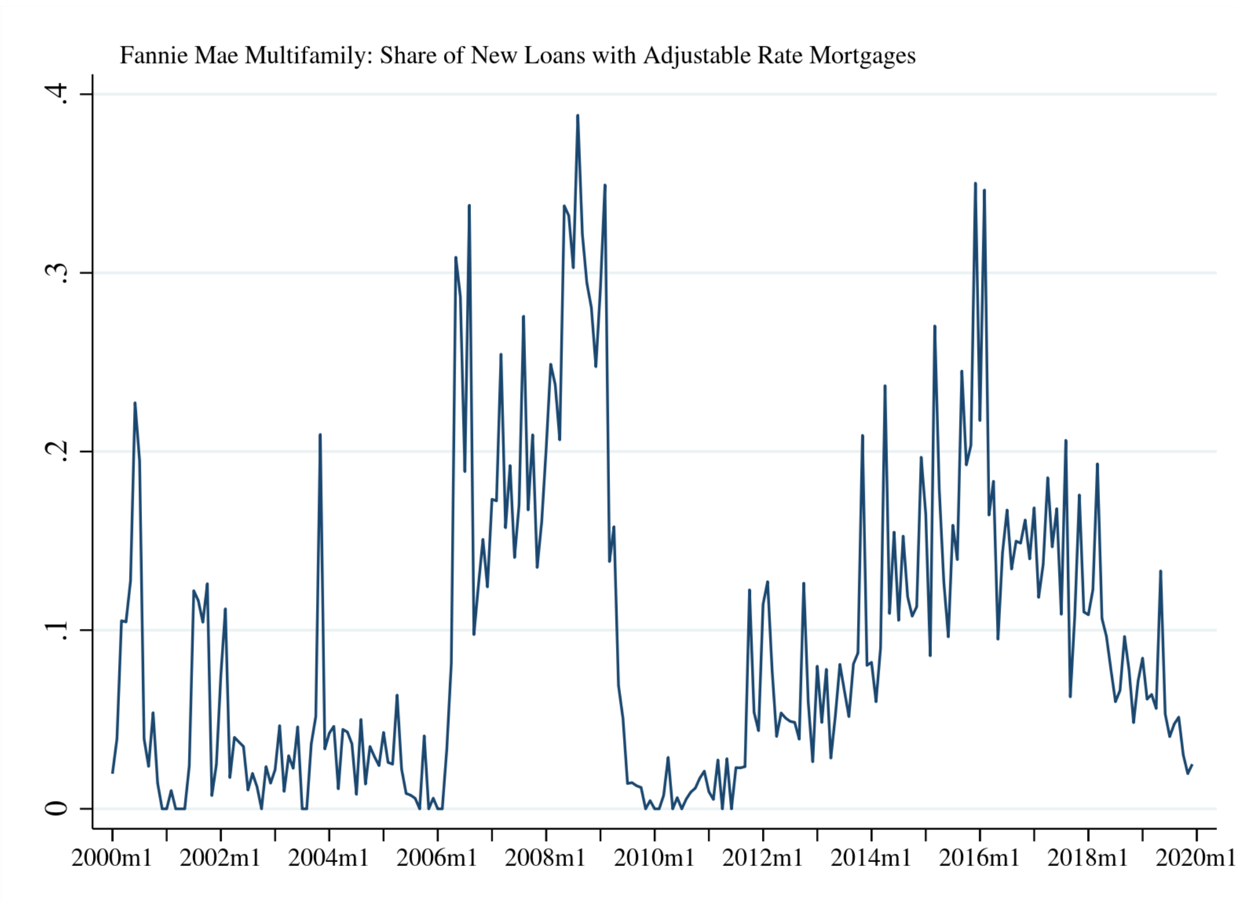
I use shifts in mortgage payments for properties with adjustable-rate mortgages, exploiting the variation provided by the rigidity of contracts in the years between origination and the first rate reset. Unfortunately, most multifamily mortgages with variable rates have floating or adjustable rates in the first 1-3 years of the mortgage term, then have the option to float, rate lock, or refinance. This analysis focuses on the relatively small group of loans who have adjustable rates where the first rate reset is in the 4th, 5th, or 6th year for mortgages with 10-, 15-, or 30-year original loan terms (including a few loans with unconventional terms between 120 and 360 months).

The unique and useful part of analyzing variation in the size of mortgage payments around the first rate reset is that landlords mortgage payment changes sharply, their cost of financing changes sharply, and their property does not undergo an appraisal. While the landlord may know that the rate reset is coming up, they do not know the direction or size of the change in mortgage payments more than a few months in advance. To understand the channels of their behavior, this section exploits heterogeneity in the responsiveness of revenues, expenses, and rents based on the landlords' liquidity constraint (whether their debt-service coverage ratio, DSCR, is below 1.25 before the rate reset), and based on their location (whether the property is located in a highly constrained market in terms of land-use regulation).

The comparison group of mortgages is constructed in a similar fashion to the I-O comparison group. The comparison mortgages were originated in the same year, though not necessarily with the same term (primarily 10-year amortizing balloon loans). The treated group includes ARMs whose first rate reset is 4 to 7 years into the loan term, allowing me to compare at least 3 years prior and 2 years past the first rate reset. I define event-time as years relative to the year in which the rate reset occurs. The main analysis uses stacked event study-style regressions of the form

$$y_{p(c)t} = \alpha_{t(c)} + \alpha_{r(c)} + \alpha_{p(c)} + \sum_{r=-2}^{5} \beta_r \times D_p^c \times \mathbb{1}_{pt}(t = r) + \epsilon_{pt} \tag{5}$$

Figure D13: Prevalence of ARMs



The regression takes property (p) by year (t) level data for ARM rate resets around cohort c (where I define cohorts by origination year and rate reset year). I recenter the dataset similar to the I-O period approach, defining event-time r as years relative to the first rate reset. The binary variable D_p^c identifies properties backed by ARMs, and the indicator function $\mathbb{1}_{pt}(t = r)$ takes the value of 1 when the current-year observation occurs r years before or after the initial rate reset. The main regression specification includes calendar year fixed effects ($\alpha_{t(c)}$), event-time fixed effects ($\alpha_{r(c)}$), and property fixed effects ($\alpha_{p(c)}$).

D.2 Changes Around the First Rate Reset for ARMs

D.2.1 Descriptive Evidence on ARM Rate Resets

To begin analyzing adjustable rate mortgages, Figure D14 shows average values of the main mortgage and property variables around the first rate reset for mortgages with a rate reset between the 4th and 7th year of the mortgage. To analyze a balanced panel, I also only include loans that are reporting their operating financials in every year for 3 years prior and 2 years after the initial rate reset. The balanced comparison group includes fixed rate mortgages where every cohort of ARMs has a cohort of FRMs that are originated in the same year and report all financial data during the same 6-year period.

The first panel of Figure D14 shows the decline in debt service payments and the decline in the actual mortgage rate applied to the mortgage around the first rate reset. The average mortgage rate reset reduces rates by nearly 2.5 percentage points (250 basis points). In real dollar terms, debt service payments decline by $70-80 from a base of just over $400 per unit per month.

The second panel shows that revenue and expenses per unit are stable in the comparison group. These figures only display tentative evidence that revenues (and expenses) may decline slightly in the year prior to the rate reset, but appear to increase in relative terms in the few years following the rate reset. A temporary decline in net operating incomes is somewhat more clear in the third panel, but reflecting the rise in revenues, net incomes rise 2-3 years after the rate reset. Once debt service payments are included, the rise in net cash flows is stark in the years after the rate reset, suggesting little or no pass-through of the decline in debt payments over a longer term.

D.2.2 Event Study & Difference-in-Difference Evidence on ARMs

This section presents the event study and difference-in-difference results for a small sample of adjustable-rate mortgages whose first rate reset occurs in the 4th to 7th year of their original loan term. I use stacked event study and difference-in-difference regressions to investigate their economic outcome and decisions.

Figure D15 shows the results of the stacked event study regressions comparing properties in ARMs to non-adjustable rate loans. Total debt service payments increase by 26% ($67) over the two years following the rate reset, while revenues decline by a non-statistically significant 4.9% ($20). This revenue decline attenuates over the next 1-2 years following the rate reset. Over the same period, expenses decline by a statistically and economically small amount, and after 2 years appear to increase by as much as 9%. It appears that the increase in revenue corresponds to in occupancy by just under 1%, however the coefficients on occupancy are not statistically significantly different from zero at any point. The net of these effects results in an decrease in net operating income of around 14% in the year of the rate reset that increases back to 5% after two years. The net income decline in dollar terms is $20 during the year of the rate reset and the year after the reset, but attenuates to an increase of $5.7 dollars two years after the rate reset. The change in net cash flows, including debt service payments, there is virtually no change in cash flows during the year prior and the year of the rate reset, then an increase in net cash flows in the years after the rate reset reflecting the decline in mortgage payments. Net cash flows increase by nearly $70, reflecting approximately no pass through of the decline in mortgage rates in the years following the rate reset.

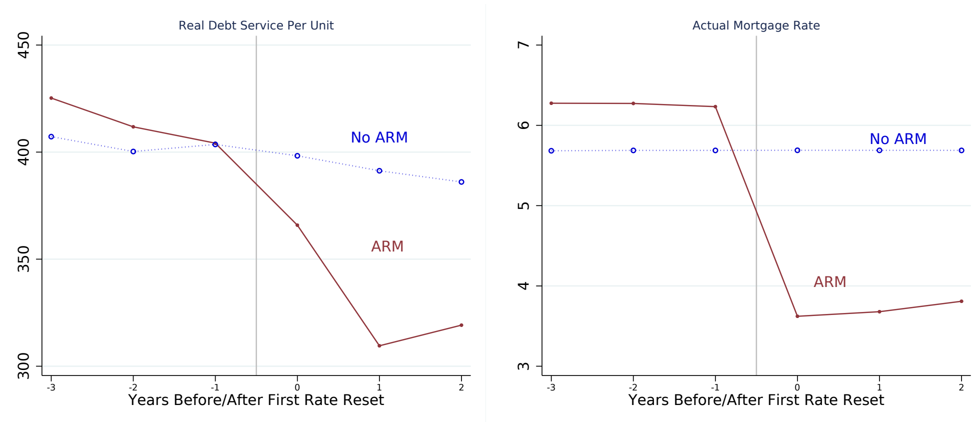
Taking the net income decline during the rate reset, we can infer a back-of-the-envelope short-term pass-through of around 30 cents per dollar increase in debt service payments. To study market prices, I use a subsample of market-rate multifamily properties merged to data from REIS on asking rents and concessions. Figure D16a shows that the ARM reset corresponds to a 2-3% increase in asking rents, and an increase in free rent concessions equivalent to about 1 month in free rent. The increase in asking rents is statistically significantly different from zero at the 95 percent confidence level in the year of the rate reset. I also report the change in vacancy rates and the log of occupied units around the timing of the rate reset. I find an increase in vacancy rates and decline in occupancy of around 2%. Because of the different subsample of properties, I will not directly compare the magnitudes to the results in Figure D15.

I next corroborate the event study results in Table D7. Unlike the interest only results, I include two indicator variables for periods $t = 0, 1$ and period $t = 2$. I would include additional time periods, but the sample is limited and there is significant attrition in the years after rate resets. Attrition is partly due to lack of reporting and in due to mortgage prepayment.

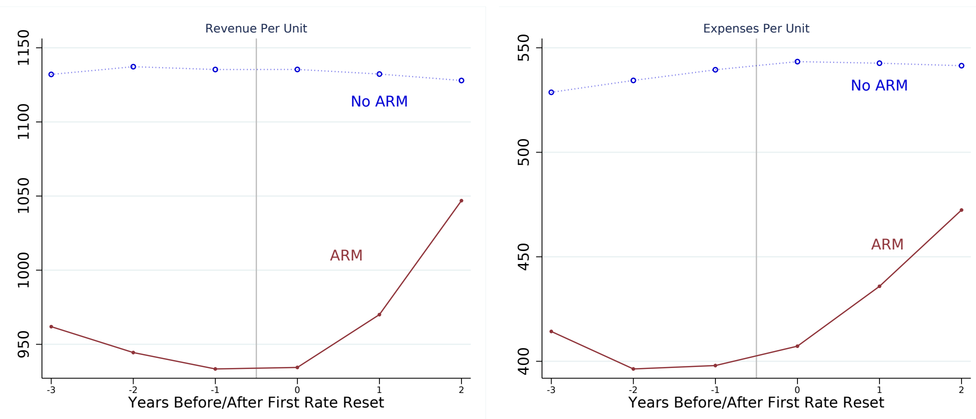
The ARM analysis is mainly intended to provide within-mortgage variation in financing costs, but the attrition of properties due to mortgage prepayment behavior after rate resets introduces additional sources

Figure D14: Change in Financials in ARMs vs Comparison Group

(a) Debt Service Payments & Current Mortgage Rate



(b) Revenue & Expenses



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

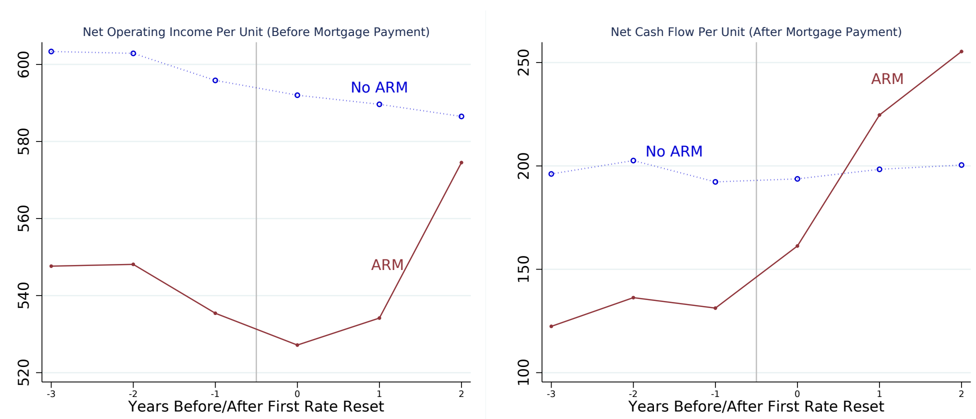
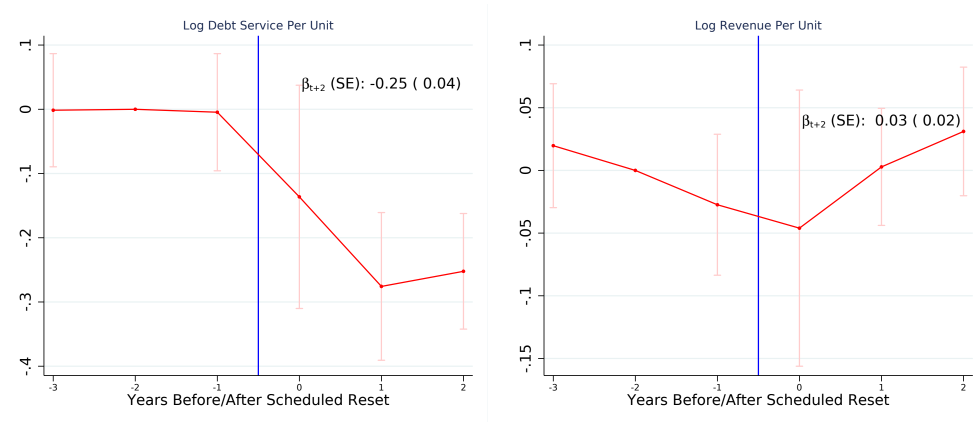
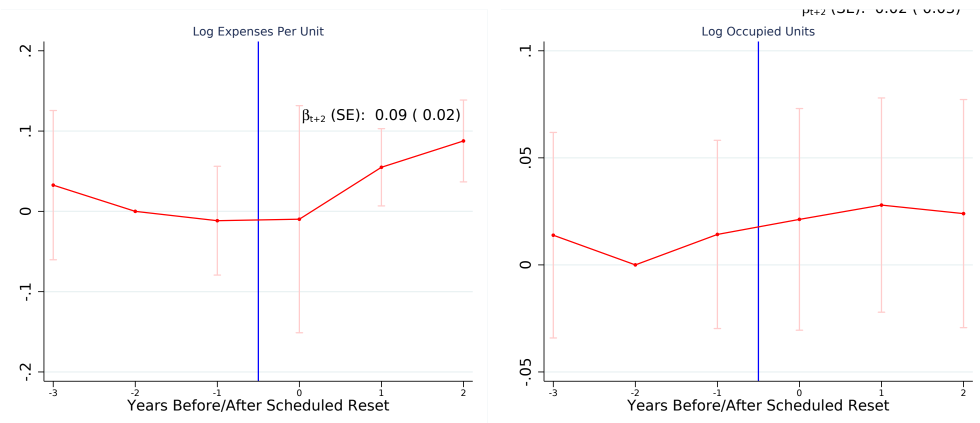


Figure D15: Event Study for ARM Mortgages

(a) Debt Service Payments & Revenues



(b) Expenses & Occupied Units



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

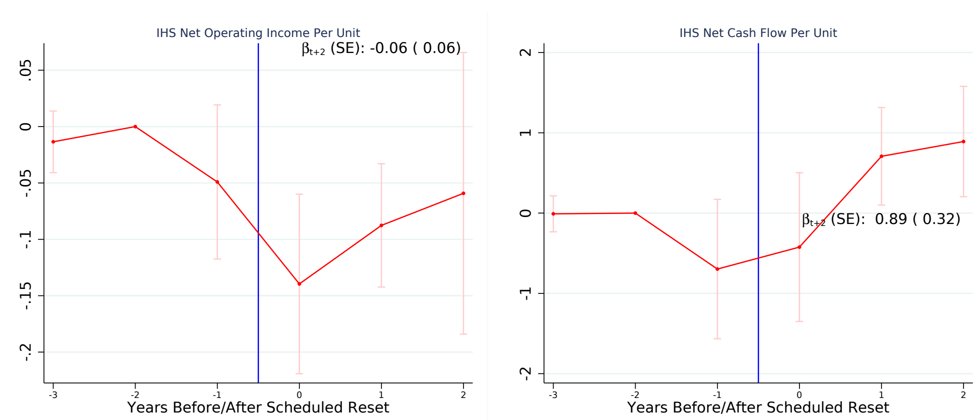
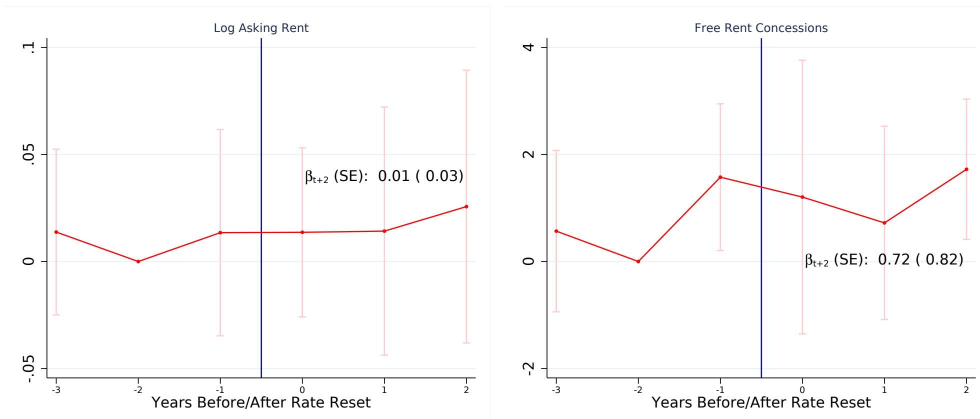
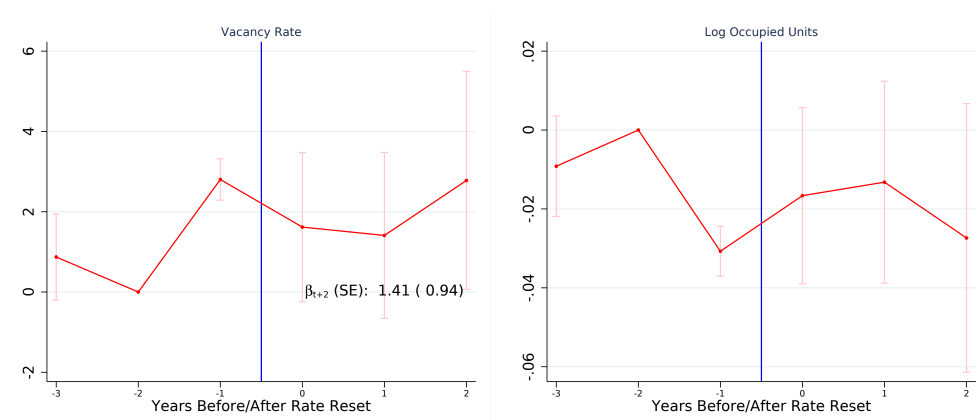


Figure D16: Trepp-REIS Subsample Event Study for ARM Mortgages

(a) Asking Rent and Free Rent Concessions



(b) Vacancy Rate and Log Occupied Units



of variation. The most important issue is the revaluation of properties at refinance or acquisition that could affect landlord behavior if they foresee a credit event in the next year or two. I discuss this in greater detail in the section on matched refinance and acquisition properties.

Table D7 compares two pre-reset years $t = -3, -2$ in event time to the 3 post-reset years. This formalizes the event study graphs above, and is similarly structured as a stacked difference-in-difference regression with a balanced panel in event time. Because the 'post-period' includes the year of the rate reset, the first column shows that the average decline in debt service payments is about 24 log points ($57 per unit-month) in the initial years and 27 log points ($75 per unit-month) two years post-reset. The next column shows the change in revenues—in log terms, revenues fall in the initial years after rate reset, but not a statistically significant amount. In dollar terms, the decline in revenues is around $30 per unit-month (significantly different from zero at the 90% confidence level). In the two post-reset years, I observe no significant change in expenses or occupied units. Net incomes decline by 8.6 log points (significant at the 95% confidence level). Once debt service payments are included, net cash flows increase by $41 dollars per unit in the initial 2 years, and by $75 dollars per unit-month by the second year post-reset, which suggests zero pass-through of financing costs to tenants after 2 years.

As in the I-O period regressions, I perform the same analysis on a sample of properties that merge the Trepp mortgage data with the REIS asking rent and vacancy data, shown in Table D8. One limitation is that because the number of ARMs is limited where there are rate resets in the middle of the loan term, I perform the difference-in-difference analysis on a balanced panel of outcomes in REIS (asking rent, vacancy/occupied units, free rent concessions), but an unbalanced panel of outcomes from Trepp (debt service, revenue, NOI, NCF). We should take these particular point estimates with a grain of salt. As in the table above, debt service payments fall on the average ARM (by $26 in the 2 years including the initial reset, falling to $76 by 2 years post-reset). As in the prior table, revenues (and NOI) fall post-reset, by $18 (and $22) per unit-month in the initial 2 years. The point estimate for the 2-year post-reset is exceptionally large and negative, likely due to attrition and weighting observations in the unbalanced panel of Trepp outcomes. For the REIS outcomes from the balanced panel, I observe an increase in asking rents, decline in occupied units, and rise in free rent concessions. The only statistically significant point estimates are for the decline in occupied units (indicating a decline of 1.9 log points), and free rents concessions (nearly a 50% rise in concessions offered to new tenants).

This evidence so far appears to be consistent with landlords that are sensitive to changes in cash flows—they appear to try to smooth cash flows on the down-side. A decline in monthly payments leads to a decline in revenues, at least temporarily. The dollar for dollar pass-through to revenue in the initial two years is between 26% in NOI or 52% in revenue terms. The asking rents results suggests that as landlords lower their monthly payments they raise rents on potential new tenants, likely lowering their occupancy rates. It seems to be consistent with landlords being willing to wait longer to fill vacancies if pressure on their costs decline (in this case, fixed monthly mortgage payments). We might expect that landlords only respond to this relaxation of debt service payments if they were cash flow constrained ex ante. I test this hypothesis in the next two tables.

In Table D9, I use an identical regression set-up, except that I interact an indicator variable that switches on if the current debt service coverage ratio in year $t = -2$ is below 1.2. This provides evidence about whether liquidity constrained landlords are more responsive to changes in their cash flows due to interest rate shifts within the same mortgage.

In the first column, we can observe that landlords who are ex ante cash flow constrained experience larger

Table D7: ARM Initial Rate Reset: Difference-in-Difference Specification

	Debt Service	Revenue	Expenses	Occupied Units	NOI	NCF
Panel A: Log and IHS Specifications						
Post (t=0,1) X ARM Loan	-0.210***	-0.035	-0.027	0.006	-0.076*	-0.072
	(0.064)	(0.038)	(0.055)	(0.009)	(0.040)	(0.432)
Post (t=2) X ARM Loan	-0.252***	0.012	0.037	0.000	-0.038	0.418
	(0.054)	(0.023)	(0.028)	(0.011)	(0.052)	(0.377)
Obs.	29190	29190	29190	29190	29190	29190
Panel B: Dollar and Level Specifications						
Post (t=0,1) X ARM Loan	-50.546***	-24.404	-12.411	3.216	-11.992	38.553**
	(15.620)	(24.783)	(18.631)	(2.076)	(11.291)	(16.447)
Post (t=2) X ARM Loan	-69.205***	1.923	5.966	2.675	-4.044	65.161**
	(17.426)	(16.112)	(10.758)	(2.486)	(16.004)	(27.575)
Obs.	29190	29190	29190	29190	29190	29190
Year-Cohort FE Property FE Event-Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are clustered by loan and year. Includes 4 years in event time; 2 years prior to reset and 2 years post reset. Relative to ARM initial reset period end year t, specification includes years: t-3, t-2, t, t+1, and t+2.

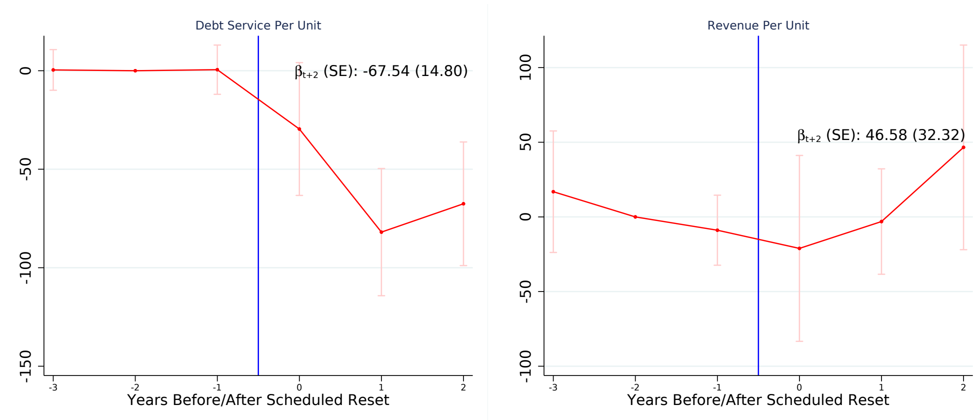
declines in debt service payments by 11 to 15 log points. The decline in revenues and NOI in the initial 2 years post-reset is almost entirely due to ex ante cash flow constrained landlords. In fact, the point estimates in dollar terms suggest that these landlords 'pass-through' 74 cents in revenue per dollar increase in mortgage payments, while the higher DSCR landlords pass-through 22 cents per dollar increase in mortgage payments. In net incomes, the difference is even starker with low DSCR landlords passing through 47%, and higher DSCR landlords passing through just 1% of the decline in mortgage payments in the initial 2 years.

Table D10 shows the analogous results for the matched REIS-Trepp sample. Again, I show but hesitate to interpret the results with Trepp financial outcomes (including revenues, NOI, and NCF) because I include properties with some missing observations from Trepp, as long as they are non-missing in REIS outcomes. The reason for including loans with missing Trepp observations is that there are relatively few properties in the matched sample. These matched regressions include 107 properties with ARMs and 1,780 comparison non-ARM properties.

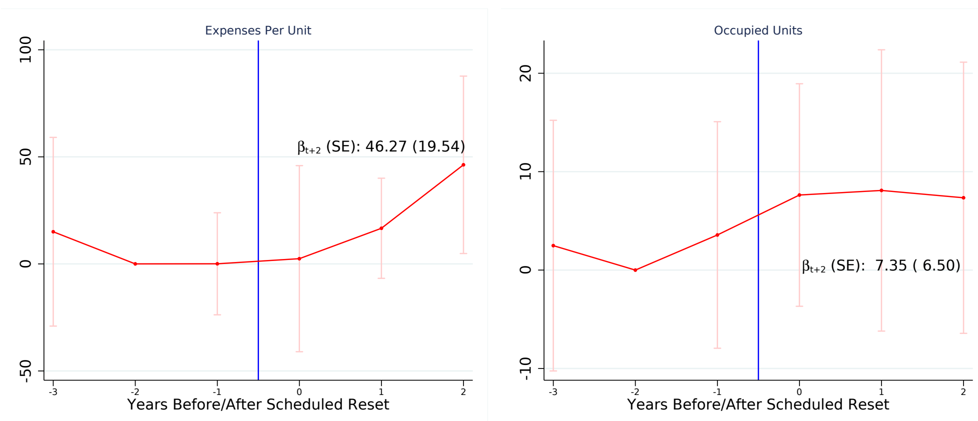
I find that asking rents rise significantly for the average property by 3.3%, but decline for ex ante cash flow constrained landlords by 2% (3.3 minus 5.3). Occupancy declines by 2.7 log points on average, but only by 0.6 for the lower DSCR landlords. It appears that free rent concessions rise, but not differentially for low DSCR landlords.

Figure D17: Event Study for ARM Mortgages in Dollar Terms

(a) Debt Service Payments & Revenues



(b) Expenses & Occupied Units



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

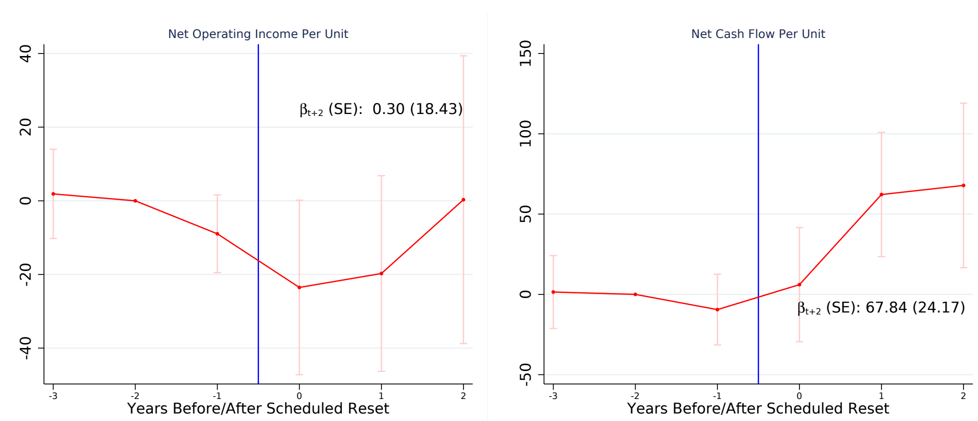


Table D8: ARM Initial Rate Reset: REIS-Trepp Subsample Difference-in-Difference Specification

	Debt Service	Asking Rent	Occupied Units	Free Rent	Revenue	NOI	NCF
			Panel A: Log and IHS Specifications				
Post (t=0,1) X ARM Loan	-0.146***	0.007	-0.012	0.198	-0.051**	-0.185	-0.768
	(0.025)	(0.020)	(0.009)	(0.232)	(0.019)	(0.140)	(0.747)
Post (t=2) X ARM Loan	-0.372**	0.019	-0.025	0.458**	-0.270	-0.506*	-0.803
	(0.167)	(0.027)	(0.015)	(0.162)	(0.163)	(0.242)	(1.137)
Obs.	6891	6975	6974	6975	6891	6886	6886
			Panel B: Dollar and Level Specifications				
Post (t=0,1) X ARM Loan	-30.365***	-1.654	-3.477**	0.679	-24.974	-26.105	4.272
	(7.534)	(24.205)	(1.355)	(0.712)	(24.562)	(15.510)	(20.681)
Post (t=2) X ARM Loan	-75.193**	-1.058	-6.487**	1.435***	-122.301	-62.402	12.798
	(31.822)	(38.186)	(2.294)	(0.465)	(104.762)	(56.589)	(50.910)
Obs.	6891	6975	6975	6975	6891	6886	6886
Property-Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are clustered by loan and year. Includes 4 years in event time; 2 years prior to reset and 2 years post reset. Relative to ARM initial reset period end year t, specification includes years: t-3, t-2, t, t+1, and t+2 Only includes properties merged on address between Trepp and REIS (covering market-rate multifamily with more than 20 units in the 50 largest cities classified by REIS).

Table D9: Liquidity Constrained Landlords at ARM Rate Reset: Difference-in-Difference Specification with Ex Ante DSCR Interaction

	Debt Service	Revenue	Expenses	Occupied Units	NOI	NCF
Panel A: Log and IHS Specifications						
Post (t=0,1) X ARM Loan	-0.164**	-0.015	-0.015	-0.004	-0.026	-0.427
	(0.063)	(0.029)	(0.045)	(0.007)	(0.029)	(0.311)
Post (t=0,1) X ARM Loan X Proj DSCR $\leq$ 1.2	-0.118**	-0.054	-0.032	0.026*	-0.128*	0.905
	(0.041)	(0.034)	(0.063)	(0.013)	(0.072)	(0.755)
Post (t=2) X ARM Loan	-0.217***	0.014	0.033	-0.009	0.001	-0.234
	(0.059)	(0.021)	(0.031)	(0.009)	(0.033)	(0.211)
Post (t=2) X ARM Loan X Proj DSCR $\leq$ 1.2	-0.091*	-0.006	0.012	0.024*	-0.101	1.671**
	(0.045)	(0.029)	(0.048)	(0.012)	(0.080)	(0.665)
Obs.	29190	29190	29190	29190	29190	29190
Panel B: Dollar and Level Specifications						
Post (t=0,1) X ARM Loan	-39.041**	-6.627	-8.610	0.886	1.982	41.023*
	(16.459)	(19.752)	(14.814)	(0.930)	(12.932)	(20.400)
Post (t=0,1) X ARM Loan X Proj DSCR $\leq$ 1.2	-29.392*	-45.422	-9.735	5.951**	-35.687	-6.295
	(14.915)	(26.566)	(24.966)	(2.753)	(23.009)	(29.648)
Post (t=2) X ARM Loan	-60.194***	13.256	1.995	0.388	11.261	71.456*
	(20.372)	(21.905)	(10.852)	(1.525)	(21.313)	(36.438)
Post (t=2) X ARM Loan X Proj DSCR $\leq$ 1.2	-23.084	-29.027	10.197	5.861**	-39.223	-16.139
	(16.336)	(31.086)	(19.692)	(2.478)	(27.836)	(36.503)
Obs.	29190	29190	29190	29190	29190	29190
Year-Cohort FE						
Property FE	Yes	Yes	Yes	Yes	Yes	Yes
Event-Cohort FE						

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are clustered by loan and year. Includes 4 years in event time; 2 years prior to reset and 2 years post reset. Relative to ARM initial reset period end year t, specification includes years: t-3, t-2, t, t+1, and t+2 Ex ante DSCR is taken as net operating income divided by debt service payments from period t-2, 2 years prior to the initial rate reset. Ex ante DSCR for the set of 108 properties with ARMs & balanced in event time around the rate reset is 1.35 on average (1.26 median). Out of 108 properties in the estimation sample, 45 have an ex ante DSCR of 1.25 or below. The comparison group includes 5,731 unique properties, of which 1,581 have ex ante DSCR below 1.2 (their overall mean ex ante DSCR is 1.52 with a median of 1.39).

Table D10: Liquidity Constrained Landlords at ARM Rate Reset: REIS-Trepp Subsample Difference-in-Difference Specification with Ex Ante DSCR Interaction

	Debt Service	Asking Rent	Occupied Units	Free Rent	Revenue	NOI	NCF
Panel A: Log and IHS Specifications							
Post (t=0,1) X ARM Loan	-0.146***	0.030*	-0.023*	0.200	-0.057***	-0.200	-1.598*
	(0.030)	(0.017)	(0.012)	(0.284)	(0.011)	(0.204)	(0.852)
Post (t=0,1) X ARM Loan X Ex Ante DSCR $\leq$ 1.2	-0.005	-0.057***	0.026**	-0.007	0.008	0.025	1.865*
	(0.034)	(0.019)	(0.010)	(0.358)	(0.021)	(0.166)	(1.001)
Post (t=2) X ARM Loan	-0.403**	0.027	-0.037**	0.449***	-0.317*	-0.587**	-1.566
	(0.170)	(0.025)	(0.015)	(0.117)	(0.162)	(0.249)	(1.230)
Post (t=2) X ARM Loan X Ex Ante DSCR $\leq$ 1.2	0.137	-0.019	0.032**	0.025	0.203	0.339	2.326*
	(0.132)	(0.034)	(0.014)	(0.206)	(0.135)	(0.224)	(1.200)
Obs.	6891	6975	6974	6975	6891	6886	6886
Panel B: Dollar and Level Specifications							
Post (t=0,1) X ARM Loan	-16.923**	10.437	-4.896***	0.596	-36.496*	-31.864	-14.931
	(7.410)	(23.554)	(1.552)	(0.894)	(17.506)	(18.250)	(22.068)
Post (t=0,1) X ARM Loan X Ex Ante DSCR $\leq$ 1.2	-31.095***	-30.584	3.526	0.206	22.686	11.692	42.790*
	(9.909)	(21.047)	(2.070)	(1.173)	(21.234)	(23.818)	(22.047)
Post (t=2) X ARM Loan	-69.953*	-11.053	-9.978***	1.302***	-158.120	-77.523	-7.564
	(35.056)	(39.313)	(2.757)	(0.359)	(95.357)	(52.892)	(41.476)
Post (t=2) X ARM Loan X Ex Ante DSCR $\leq$ 1.2	-6.159	25.170	8.752**	0.332	143.999	59.652	65.813
	(30.104)	(49.930)	(3.544)	(0.662)	(122.887)	(75.564)	(65.635)
Obs.	6891	6975	6975	6975	6891	6886	6886
Property-Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are clustered by loan and year. Includes 4 years in event time; 2 years prior to reset and 2 years post reset. Relative to ARM initial reset period end year t, specification includes years: t-3, t-2, t, t+1, and t+2 Ex ante DSCR is taken as net operating income divided by debt service payments from period t-2, 2 years prior to the initial rate reset. Ex ante DSCR for the set of 108 properties with ARMs & balanced in event time around the rate reset is 1.35 on average (1.26 median). Out of 108 properties in the estimation sample, 45 have an ex ante DSCR of 1.25 or below. The comparison group includes 5,731 unique properties, of which 1,581 have ex ante DSCR below 1.2 (their overall mean ex ante DSCR is 1.52 with a median of 1.39). Only includes properties merged on address between Trepp and REIS (covering market-rate multifamily with more than 20 units in the 50 largest cities classified by REIS).

E Appendix: Behavioral Rent-Setting & Mis-Optimization

This section presents two main pieces of descriptive evidence that many landlords are behavioral rent-setters who mis-optimize their prices and leasing behavior often enough to systematically affect rental housing markets. 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 E18a, 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 E18b 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 E19a & E19b 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.

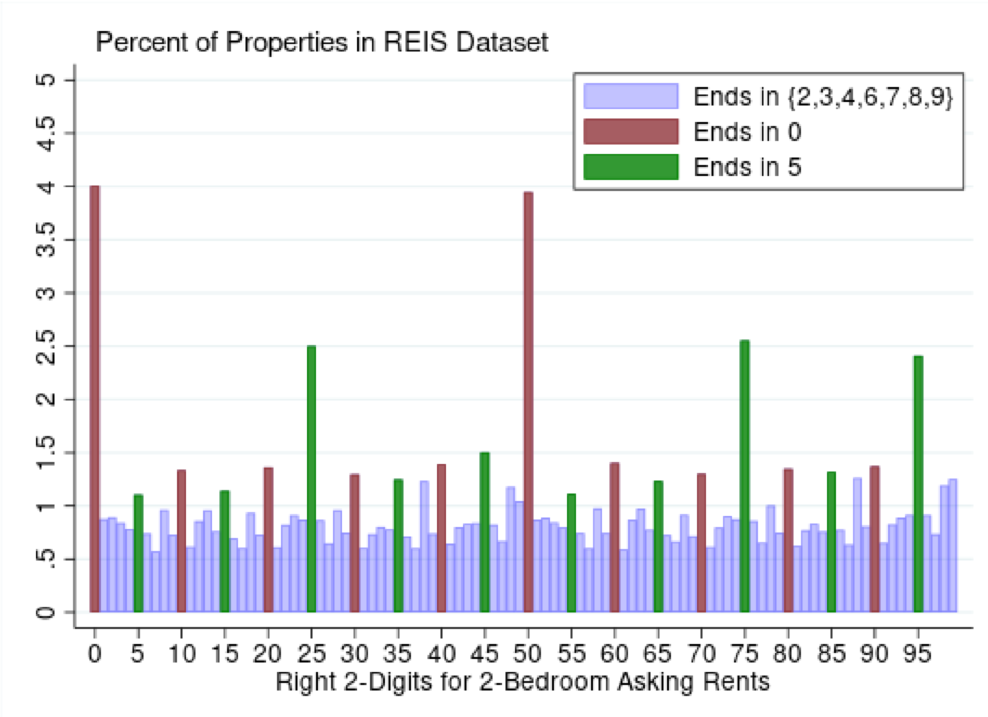
Figure E20a & E20b shows histograms of the residuals from the regressions described above. There is substantial dispersion in both asking rents and vacancy rates. I provide some summary statistics for the size of this dispersion: 25% of properties have rents per square foot more than 0.25 cents from 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 E11, 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 E12 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 vacancy is related to about 0.02 percentage points lower asking rent growth. The final column shows that

Figure E18: Round-Number Bunching in Asking Rents

(a) Right 2 Digit Bunching of Asking Rents



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

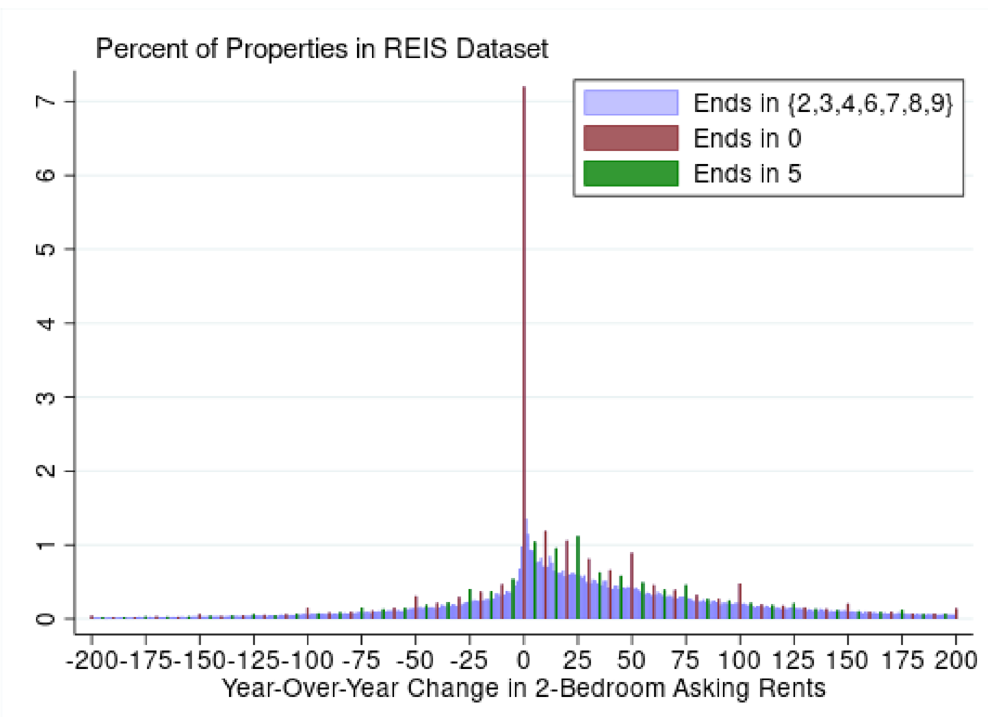
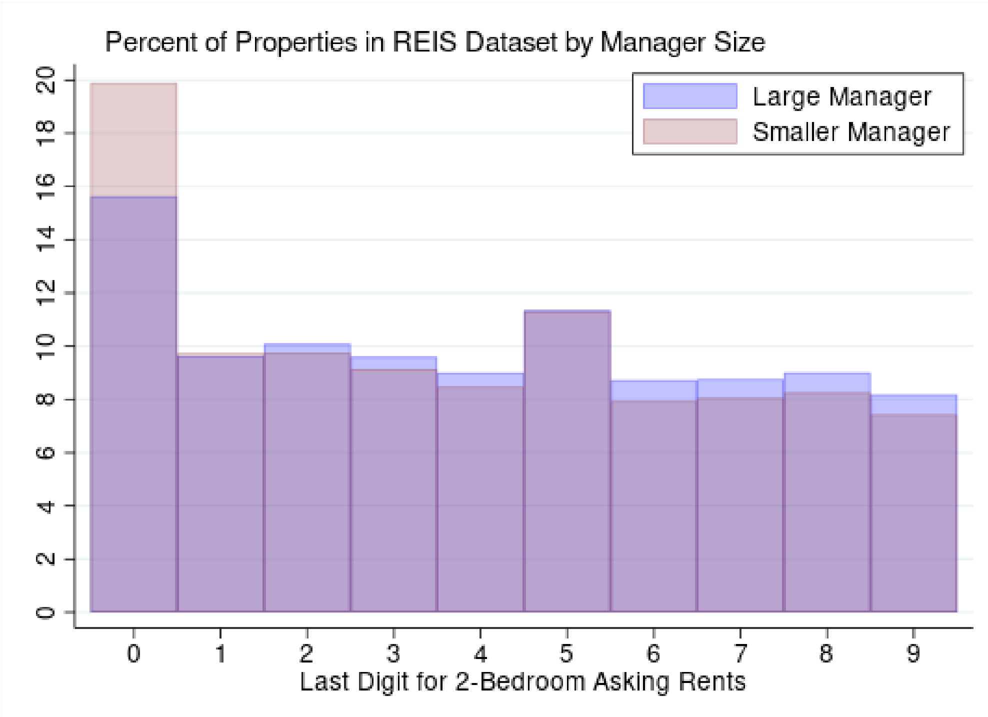


Figure E19: Round-Number Bunching in Asking Rents by Manager Size

(a) Last Digit Bunching of Asking Rents



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

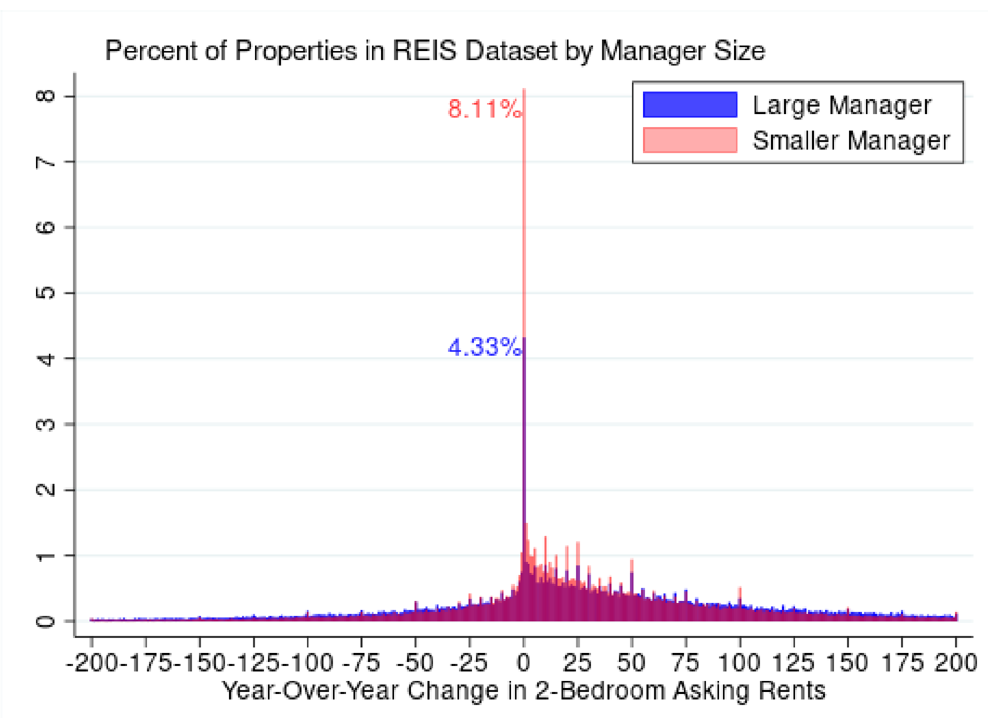
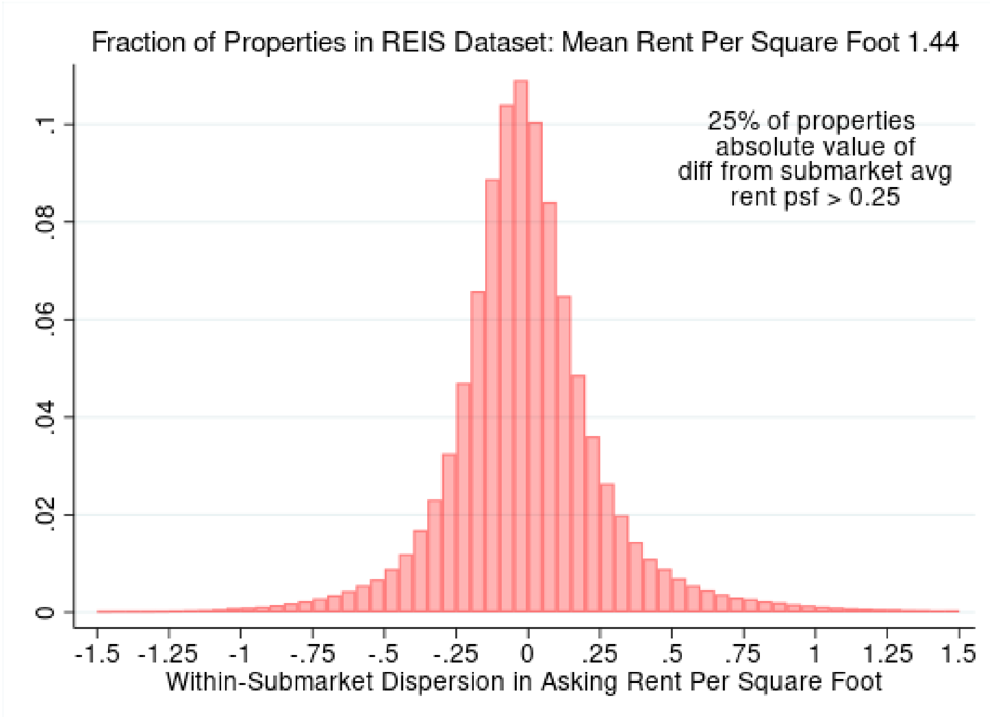


Figure E20: Within-Submarket Dispersion in Prices and Quantities

(a) Asking Rent Per Square Foot Dispersion



(b) Vacancy Rate Dispersion

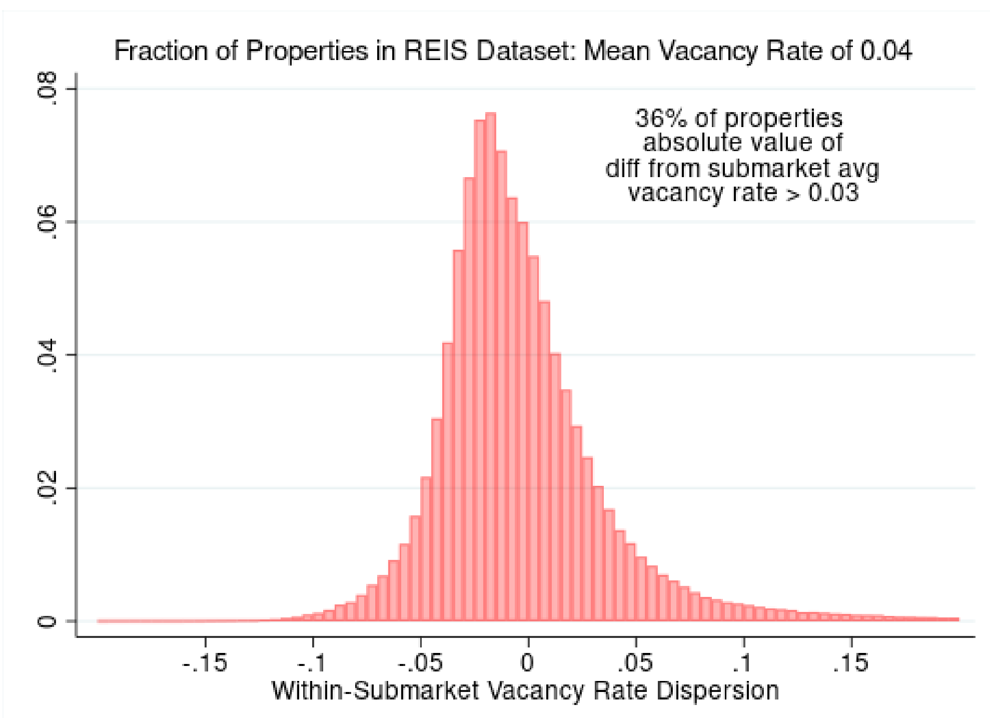


Table E11: Persistence in Asking Rent and Vacancy Differentials

	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.

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 E12: 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.

F Appendix: Alternative Rent Indices for CBSA Exposure Regressions

Here I replicate the specifications from Section 7 using additional rent indices.

We learn several additional lessons from these regressions. Table F14 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 F13: 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 F14: REIS Asking Rents: CBSA Exposure to Interest Rates and Prepayment and Maturity

	OLS			TWFE		
Share of Mortgages Prepay/Matured	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.

G Appendix: How Much Do Appraisal Values Reflect Fundamentals Versus Asking Rents?

To explain landlord behavior around prepayment, I find movements in asking rents that sometimes diverge from moves in revenues or net income. One way to reconcile this is that property valuation depends on asking rents in a way that is independent of net incomes. This could be possible if lenders, appraisers, and underwriters use asking rents as a heuristic or fundamental indicator of property income potential.

There are at least 3 plausible channels by which landlords' asking rent choice 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 925 observations meeting all of the data requirements to be included.

Table G15 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.

While Table G15 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

Table G15: Trepp-REIS Merge: Sensitivity of Appraisal Values to Asking Rents

	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. Standard errors are robust.

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 G16. 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 G15, Columns 5-8. However, in Table G16 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.

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 G17, 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.

Table G16: 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.

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 6 on how property outcomes and landlord behavior change in response to financing cost shocks.

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 G18, 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 G19. 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

Table G17: 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.

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 G20 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 G18: 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 G19: 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 G20: 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.

H Appendix: Landlords' LTV & Cash-Out at Credit Events

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.

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 H22, 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).

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

Figure H21: Mark-to-Market LTV Before Refinance and Actual Change in Appraised Value

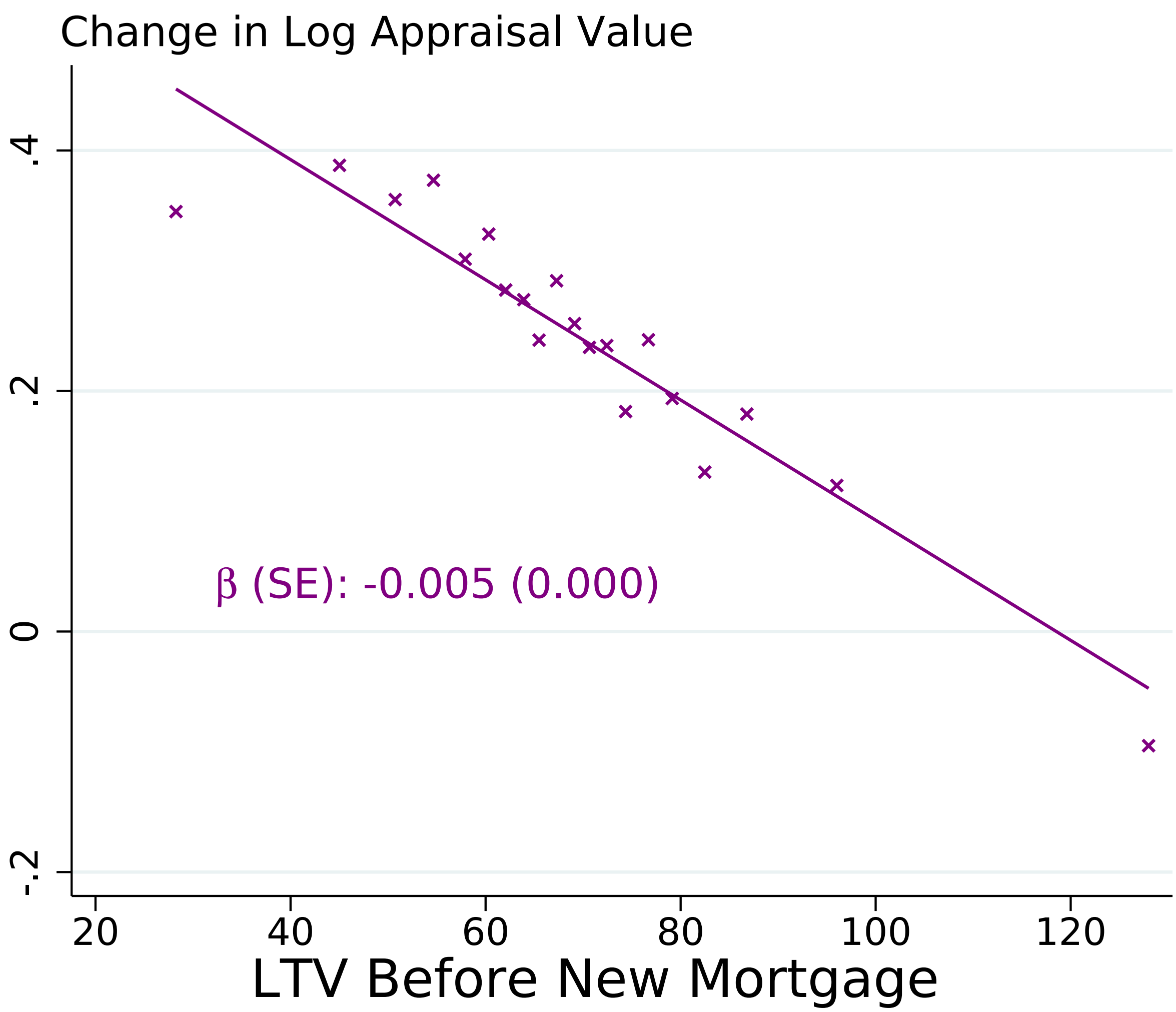
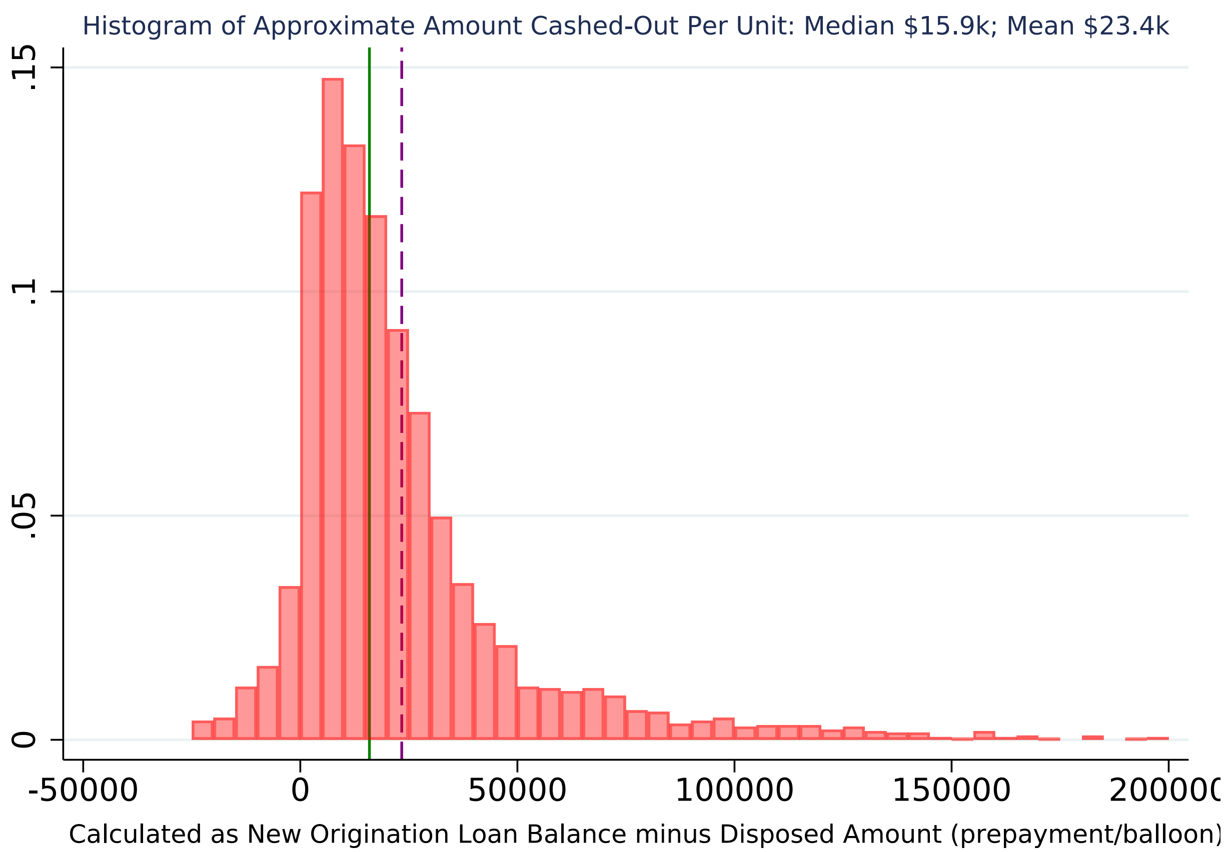


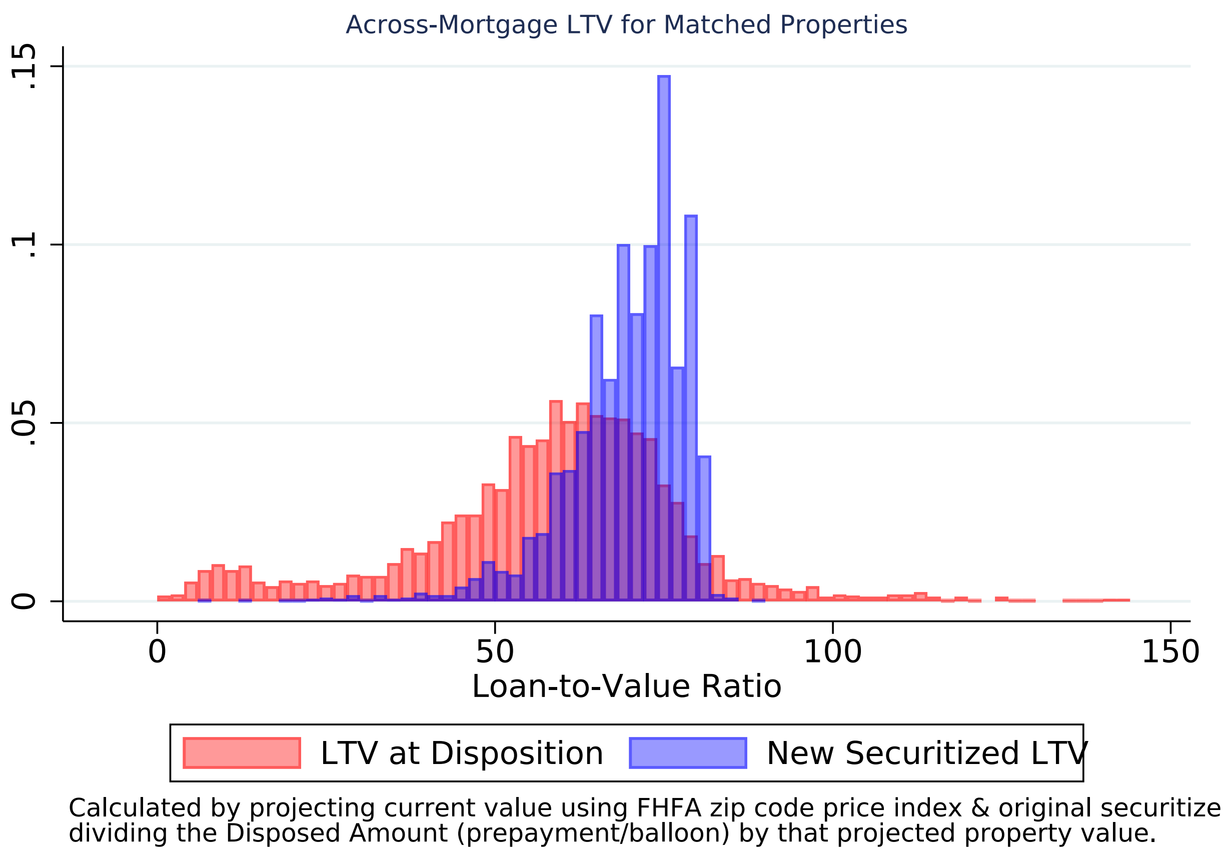
Figure H22: Histogram of Change in Property Equity (Net Cash-Out Amonut)



the property's value.

Figure H23 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 H23: 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 a component of cap rates is either risk premiums or cost of debt. There is only limited evidence on within-property changes in cap rates and

Figure H24: Mark-to-Market LTV Before Refinance and Actual Cash-Out

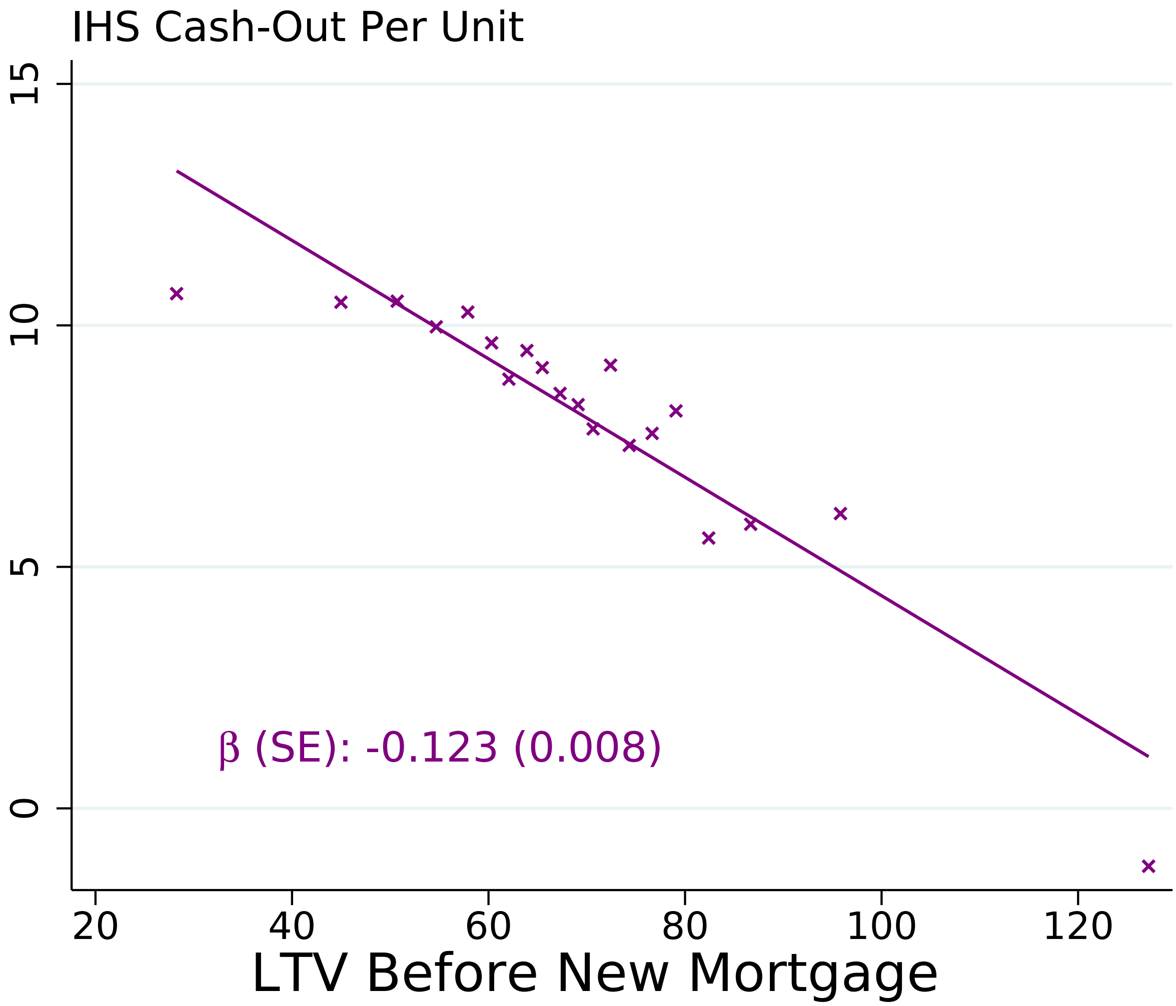
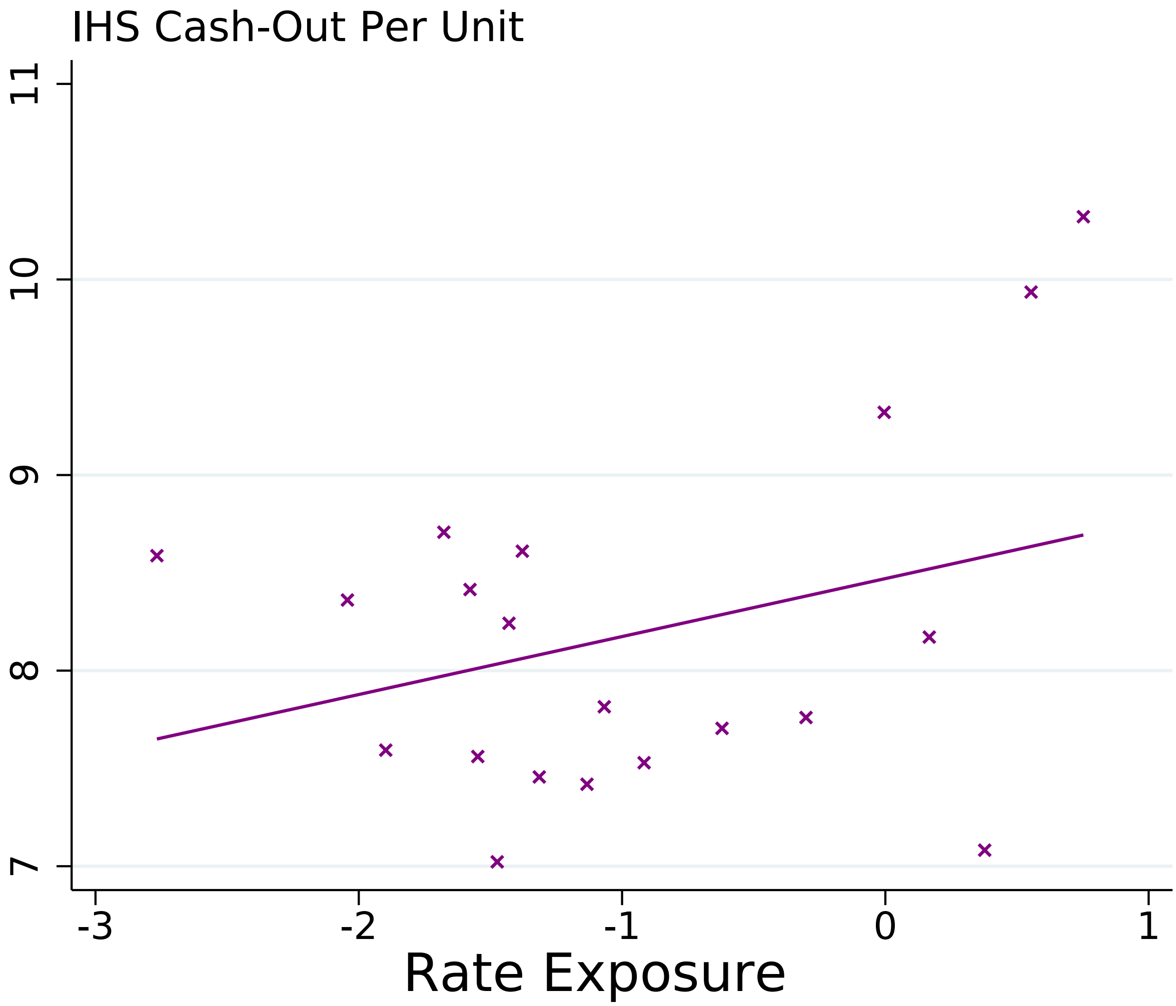


Figure H25: Rate Exposure and Actual Cash-Out



the cost of debt. 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 graphs show compelling evidence that leverage and cost of debt shift cap rates. Higher leverage properties appear to trade at higher cap rates. Increases in mortgage rates appear to increase cap rates with a slope of 0.2 to 0.3. This suggests that the mortgage rate to cap rate relationship is substantial but it is significantly less than one-for-one.

Figure H26: Mark-to-Market LTV Before Refinance and Change in Cap Rate

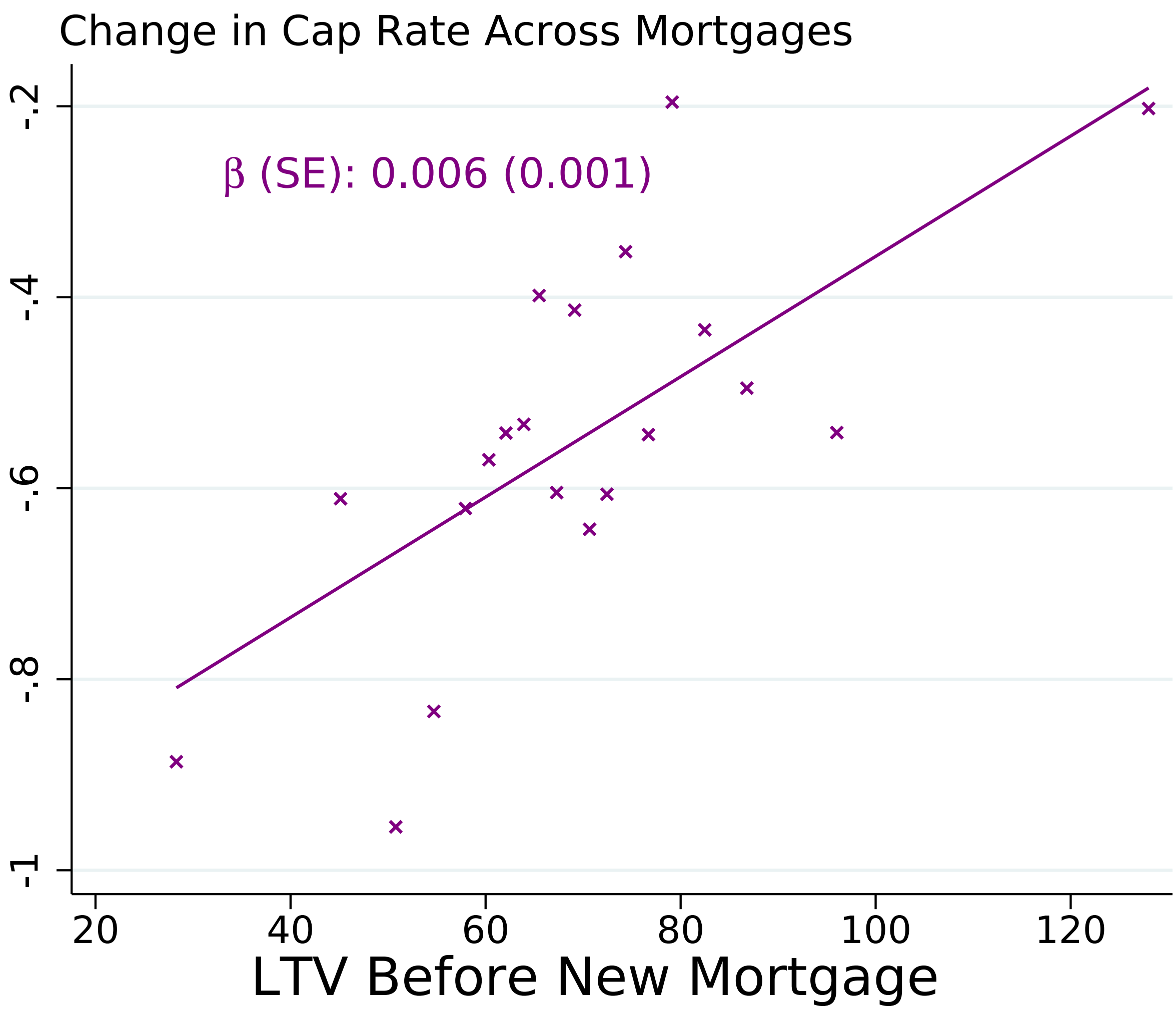
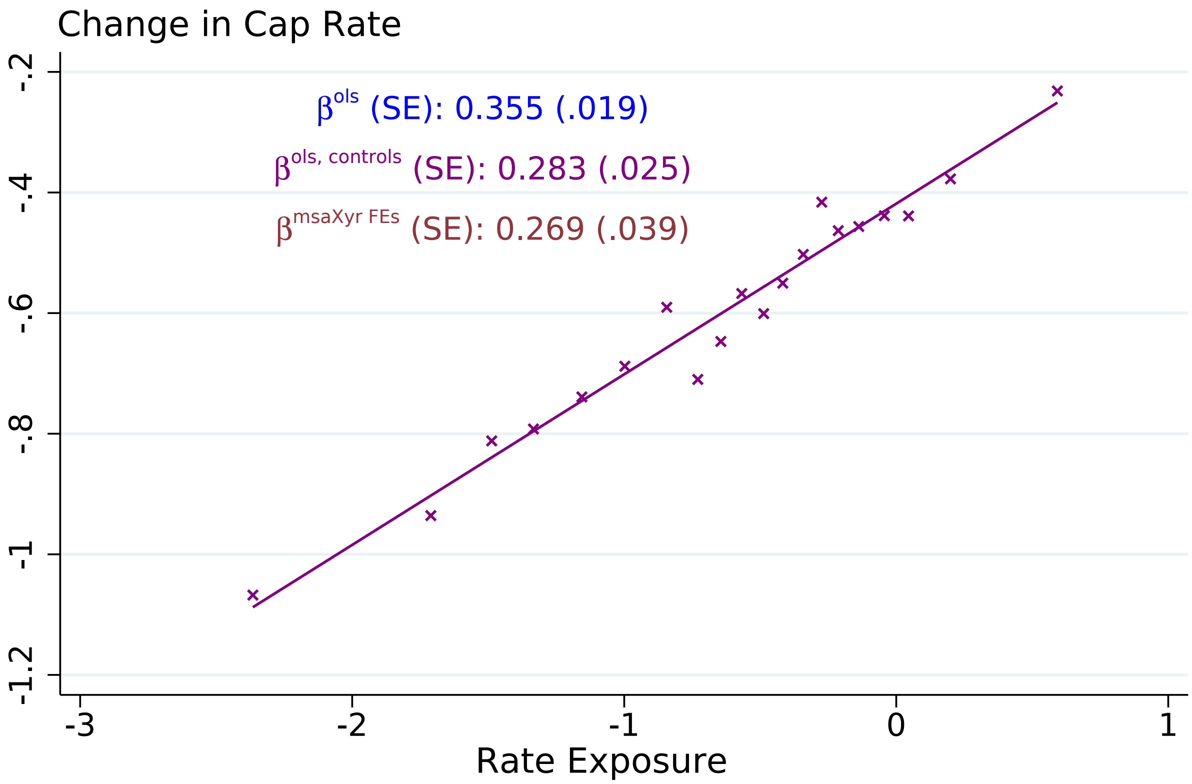


Figure H27: Rate Exposure and Change in Cap Rate



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.