Bleaker on Broadway: The Contractual Origins of High-Rent Urban Blight

Daniel Stackman and Erica Moszkowski

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Abstract

We document the rise of storefront vacancies in prime retail locations, a phenomenon we refer to as high-rent blight, in America's largest and most expensive urban retail market: Manhattan. We identify a little-known contracting feature between retail landlord and their bankers that generates vacancies in the downstream market for retail space. Specifically, widespread covenants in commercial mortgage agreements impose rent floors for any new leases landlords may sign with tenants, short-circuiting the price mechanism in times of low demand for retail space. Quasi-experimental estimates suggest that binding rent floors imposed by mortgage covenants substantially reduce the probability of occupancy, and we show in counterfactual exercises that covenants may have increased vacancy rates by as much as 14% over the 2016 to 2020 period.

1 Introduction

Some time in the 2010s, amidst generally favorable macroeconomic conditions, for cities in particular, journalists and policy makers began to notice a disturbing trend. Prominent articles, warning of a "retail apocalypse", documented increasing numbers of vacant brick-and-mortar retail outlets. While in some locations, this trend no doubt reflected the inevitable obsolescence of brick-and-mortar store in an age of e-commerce, this phenomenon was not limited to malls in suburbia. Indeed, some of the most expensive real estate in the world, ground-floor retail spaces in Manhattan, remain vacant for years. In response to a perceived retail vacancy crisis, policy makers across various cities, including Los Angeles, San Fransisco, and Washington D.C., have instituted taxes on vacant storefronts, and there are similar proposals being considered in New York.

According to data released by the New York City Department of Finance in 2019, vacancy rates in Manhattan are highest in census-tracts with the highest rents per square foot. Landlords appear to be leaving tens of millions of dollars in foregone rents on the table. This specific phenomenon, of vacancies being the highest in the most desirable, and thus, the highest rent locations, is what we term *high rent blight*. While several factors are likely implicated in high rent blight, including regulatory frictions created by local land use rules, and search and matching frictions between landlords and tenants, we focus on a relatively under-explored explanation: nominal rent rigidities created by covenants in commercial mortgages.

A majority of commercial buildings in New York are financed by mortgage debt. In addition to standard financial terms like the mortgage origination amount, the interest rate, and the loan maturity date, it is also standard for commercial mortgages to contain covenants prescribing how landlords should lease out their spaces. In particular, we document the existence of covenants that forbid landlords from leasing their vacant spaces to tenants at "below market" rents. These covenants effectively freeze asking rents for

retail spaces at the time of mortgage origination, which prevents the price mechanism from clearing the market in the event of a decline in demand for retail space. Moreover, these nominal rent rigidities are most likely to bind precisely in those neighborhoods that have had a history of relatively high rents – exactly what we observe in the data.

First, to understand the purpose of these covenants, we write down a simple, two-period model of borrowing, lending, and leasing, and show how rent-floor covenants can arise as a partial solution to agency problem created by limited liability. We document, for the first time, the systematic negative relationship between covenant rent-floors and vacancy-filling probabilities. Next, to understand the quantitative impact of rent-floor covenants on leasing behavior, and the overall level of vacancies, we construct a dynamic, structural econometric model of both landlords' leasing and borrowing / default decisions, as well as banks' mortgage lending decisions, and we estimate this model using data we have collected on storefront occupancy, rents, and outstanding mortgages.

The remainder of the paper is organized as follows: Section 2 provides a description of the industry. Section 3 presents a stylized version of the model, to illustrate the key forces that make covenants potentially appealing for banks. Section 4 describes the data used, and Section 5 presents descriptive evidence of the importance of the covenant rent-floor mechanism. Section 6 presents the full model that will be taken to data and estimated. Section 7 presents the empirical strategy employed and the estimation results. Section 8 provides the counterfactual experiments, and Section 9 concludes.

2 Industry details

3 Stylized model

Consider the following stylized model, which takes place over three periods. At time 0, a would-be landlord, endowed with initial equity $E > 0$, has the chance to buy a vacant retail property for a price $W_0 > E$. To finance this purchase, he may borrow $M = W_0 + E$ from a bank today, entitling the bank to a balloon payment $B \geq M$ in two periods, and collateralized by the retail property. For simplicity, we assume both the landlord and the bank are risk-neutral and discount the future at the same rate $\beta \in (0, 1)$, and we abstract from interim interest payments or amortization of the loan.

Assuming the loan and purchase are made at time 0, at time 1, the landlord is randomly matched with a tenant who offers to pay a rent of p per period to lease the retail space for two periods. Tenants are fully characterized by their rent offers p, and are drawn from a distribution with cdf $F(p)$. If the landlord accepts the tenant's offer, then he pays a leasing cost c, earns rent p, and continues on to time 2. At the beginning of time 2, the landlord decides whether to repay the loan and liquidate the property, or to default, and hand over the property to the bank.

Reasoning backwards, at time 2, the landlord will only repay if the value of the retail property exceeds the amount of the balloon payment, $W_2 > B$, otherwise, he will default. The value of the property at time 2 is a function of whether or not the property has been leased out, and at what rent. In a slight abuse of notation, we denote

$$
W_2 = \begin{cases} W(0) \equiv W_0 & \text{if the retail space is vacant} \\ W(p) & \text{if the retail space has been leased at rent } p \end{cases}
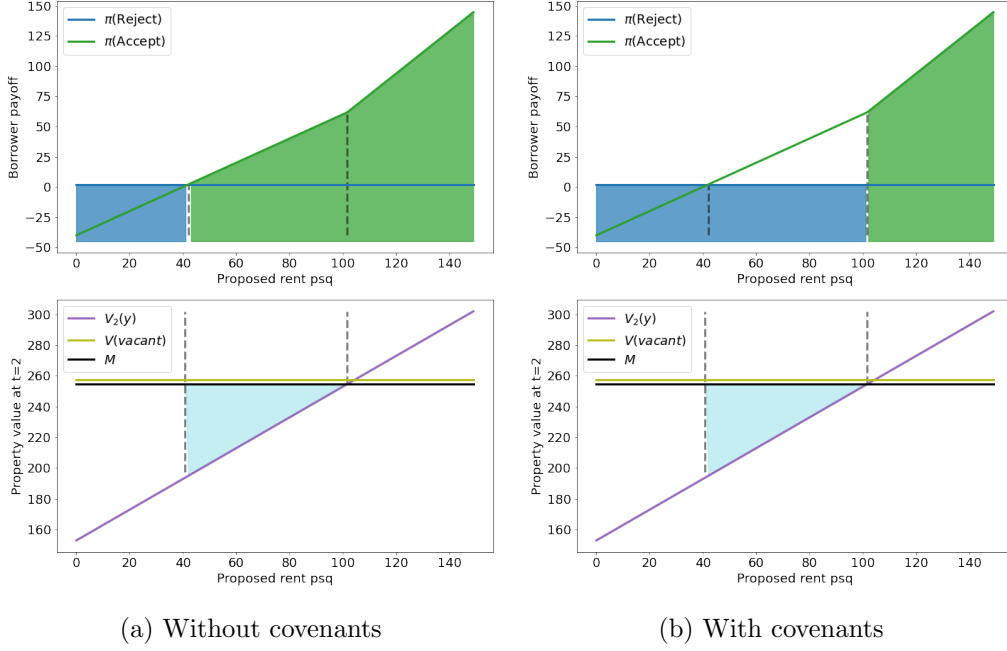$$

(a) Without covenants   (b) With covenants

Figure 1: Moral hazard

and the default policy d

$$d(p) = \mathbf{1}\{ \underbrace{W(p) - B}_{\text{repayment payoff}} < \underbrace{0}_{\text{default payoff}} \}$$

Note that $W(0)$ denotes the value of a vacant space, not the value of space leased at rent $p = 0$ (a space would never lease at 0 due to the leasing cost $c > 0$). Taking default decisions at time 2 as given, at time 1, a landlord facing a rent offer of p makes the leasing decision

$$\max_{\ell \in \{0,1\}} \left\{ \ell \cdot \underbrace{(p - c + \beta(1 - d(p))(W(p) - B))}_{\text{leasing payoff}} + (1 - \ell) \cdot \underbrace{\beta(1 - d(0))(W(0) - B)_+}_{\text{rejection payoff}} \right\}$$

Assuming the property value $W(p)$ is increasing and continuous in p (except at 0), the landlord's optimal leasing policy is to follow a cutoff rule: $\ell = 0$ if and only if $p \geq c + \beta\big((W(0) - B)_+ - (W(p) - B)_+\big)$.

The top left panel of Figure 1 depicts the landlord's payoffs as a function of the offered rent p. In blue, we have the payoff associated with rejecting the offer and remaining vacant, which is constant in p, while in green, we have the payoff associated with accepting the rent offer, which is increasing in p, with at kink at the point where the value of the leased-out property exceeds the balloon payment B. From the landlord's perspective, it is optimal to lease out the space at any $p \geq p_{LL}^* \equiv c + \beta\big((W(0) - B)_+ - (W(p_{LL}^*) - B)_+\big)$, shown as the green shaded region in Figure 1. The first vertical dashed line in Figure 1 shows the location of p_{LL}^*.

However, this arrangement is not appealing to the bank. In the event of default, the bank will become the owner of the building, so if, in the second period, the building

is worth less leased-out than it would have been worth vacant, the landlord's leasing decision has impaired the value of the collateral. The bank wants the landlord to follow a different cutoff policy: namely, the bank only wants the landlord to lease out the space if $W(p) \geq \min\{B, W(0)\}$. Denote the bank's ideal cutoff p_B^*. The bottom left panel of Figure 1 illustrates the banks payoffs. For all $p_{LL}^* \leq p < p_B^*$, the landlord wants to lease the space, while the bank wants the space to remain vacant, since for any such p, the landlord will default at time 2 and the bank will have to dispose of the mortgaged property at a loss (shaded teal area). Therefore, if covenants regulating what kinds of rent offers landlords may accept are part of the mortgage contract space, for any B, banks would choose to impose p_B^* as a rent floor. This makes the loan riskless from the bank's perspective, but it also results is fewer rent offers being accepted. We can see this in the top right panel of Figure 1, illustrated by the much larger blue shaded area.

For any initial loan amount M, the bank's problem is to choose B to maximize the expected return on lending, subject to the landlord's incentive compatibility and individual rationality constraints:

$$\max_B \mathbb{E}\big[(1 - d(p)) \cdot B + d(p) \cdot (\ell(p)W(p) + (1 - \ell(p))W(0))\big]$$

subject to
$$E \leq \mathbb{E}\big[\ell(p) \cdot (p - c) + \beta\big(\ell(p)(1 - d(p))(W(p) - B) + \\ (1 - \ell(p))(1 - d(0))(W(0) - B))\big] \qquad (\text{ IR})$$
$$d(p) = \mathbf{1}\{B > W(p)\} \qquad (\text{IC1})$$
$$\ell(p) = \mathbf{1}\{p \geq p^*\} \qquad (\text{IC2})$$

where $p^* \in \{p_L^* L, p_B^*\}$ is the leasing threshold for the landlord, or for the bank, depending on whether covenants have been imposed. For the landlord to participate, the expected payoff from borrowing must exceed the value of the initial equity E (IR), and when choosing the balloon payment B, the bank must take into account the landlord's optimal default and leasing behavior (IC1 and IC2, respectively). Finally, if we denote the bank's optimal choice of the balloon payment with B^*, it must be the case that

$$\beta\mathbb{E}\big[(1 - d(p)) \cdot B^* + d(p) \cdot (\ell(p)W(p) + (1 - \ell(p))W(0))\big] \geq M$$

In other words, to be willing to lend, the bank's expected discounted payoff must weakly exceed M. Perfect competition in the banking sector, assumed here for simplicity, ensures that this participation constraint above holds with equality.

Up until now we have consider the case of a single landlord with initial equity E, but suppose instead that there are a continuum of landlords, each differing in their equity endowment $0 \leq E \leq W_0$. With rent-floor covenants, banks will lend up to $\beta \times 100\%$ of the collateral value, and so all landlords with equity $(1 - \beta)W_0 < E < W_0$ receive financing, because the covenants have made the mortgage riskless. In the absence of covenants, banks must be compensated for default risk, so the corresponding balloon payment B will be higher, compared to a loan with covenants. Moreover, at high enough loan-to-value ratios, it may be the case that the marginal landlord who receives financing may have equity strictly less than the collateral value $E < \beta W_0$. Such a situation is pictured in Figure 2.
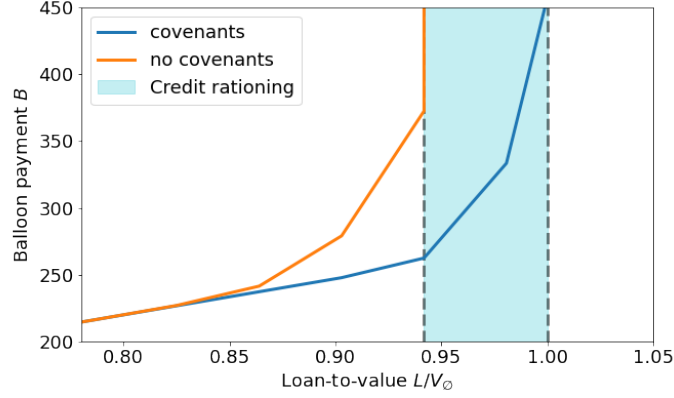
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Figure 2: Credit supply curves, with and without covenants

From a social planner's perspective, there is a tradeoff: mortgage covenants that impose rent floors lead to additional vacancies, but in their absence, moral hazard arising from limited liability leads to credit rationing. The credit supply curve shifts inward, and goes vertical at a lower initial loan balance, resulting in higher repayment costs and less overall lending, compared to a world with covenants. This means that without covenants, some acquisitions are never financed, even though they would be profitable for the would-be landlord.

In this section, we have outlined a simple contract theory model that demonstrates the economic rationale for mortgage covenants that impose rent-floors. This model was simple enough to provide intuition, but too simple to be confronted with actual data. Therefore, in the next section, we build up a flexible structural model of landlords, banks, and tenants, that can actually be estimated and used to construct counterfactuals.

4 Data

In this paper, we combine data on vacancies, lease contracts, and commercial mortgages from three separate sources. We obtain data on storefront occupancy and vacancy from Live.XYZ. This dataset tracks how storefronts in New York City change over time between 2016 and March 2020, using a combination of web scraping, phone calls, and in-person visits to the stores themselves. The main advantage of the Live.XYZ dataset over other retail store trackers (such as Infogroup, Yelp, or Google Reviews), is that it allows us to observe vacancies directly, rather than inferring them when data on a given store is not present. Also, it contains information on nearly the universe of storefronts in neighborhoods it covers, though Live began covering different neighborhoods at different times.

The Live.XYZ dataset assigns each storefront, or space, a unique identifier. Storefront occupants, or places, also have unique identifiers. This allows us to track tenant changes, as well as transitions between vacancy and occupancy, at the sub-building level. The ?state? of a storefront consists of several components: whether it is occupied, under construction, or vacant; the place (tenant) that occupies it, if there is one; and whether or not the tenant is operating, coming soon, closing soon, temporarily closed, or permanently closed. Each observation in the dataset is a unique space-place-state observation, and is assigned a start time and an end time. However, the start and end times are censored at the dates that Live XYZ first observed and last observed the space. Therefore, if a store had been located in a given space before Live first observes it, we do not observe how long it has been there.

The Live.XYZ dataset also contains useful information about physical features of each storefront. It flags whether the main entrance is exterior to the building (leading directly onto the sidewalk) or in the interior (so that visitors have to go through part of the building to get to the store). We also see the exact latitude/longitude location of the door, from which we can tell whether the primary entrance is on an east-west cross-street (which are usually narrow and have less pedestrian and vehicle traffic) or on a north-south avenue (which are wider streets with more foot traffic).

Our second dataset consists of a crowdsourced sample of lease contracts from CompStak. The dataset contains information on rent per square foot, square footage, address, landlord name, tenant name, and rent concessions, as well as lease execution, commencement (move-in), and expiration dates. We observe two versions of rent per square foot: the starting rent (the rent charged in the first month the tenant occupies the space, before incorporating any concessions) and the effective rent (which factors in rent step-ups as well as concessions). In some cases we see the entire contractual rent schedule.

The leases we observe are crowdsourced from commercial real estate brokers. Brokers have an incentive to report on leases they have been involved with because, the more information they provide, the more data they are able to see. While Compstak launched in 2012, brokers are able to report on leases going much further back in time. Our dataset covers leases with commencement dates from 2005 through February 2020.

Our final dataset contains property records from New York City's open-access Automated City Register Information System (ACRIS), which is administered by the Department of Finance. This dataset contains documents that impact rights to real property and must be filed with the City Register, including deeds and mortgages. We therefore observe changes in property ownership, as well as all new mortgages (including refinances) and mortgage satisfactions. However, the City Register filing only records the date the mortgage was issued and the total amount of the loan. ACRIS does not report on the interest rate or

term of the loan. We use the ACRIS data to construct a panel of lending activity at the property-quarter level.

ACRIS also contains PDFs of commercial mortgage documents. We downloaded these PDFs and used OCR software to convert them to machine-readable text documents. Using natural language processing algorithms, we attempted to detect language restricting landlords? leasing behavior. We detect such language in 35-45% of all mortgage documents. However, this is almost certainly a lower bound on the frequency of tenancy covenants, since OCR technology is error-prone and there are many ways to phrase tenancy covenants that our analysis may miss. Furthermore, real estate lawyers, landlords, lenders, brokers and industry analysts have all described these covenants as standard.

Our data is limited in a few dimensions. First, since occupancy panel is very short, we do not observe tenant exit or survival for every lease in the lease dataset. Second, since we only observe a sample of lease contracts, we do not have complete rent histories for every storefront. We therefore divide Manhattan into geographic submarkets and define market clearing rents for each submarket-quarter as the average rent per square foot of leases signed that submarket-quarter. The geographic submarkets we use can be seen in Figure 3, and are aggregations of real estate submarkets defined by CompStak. We feel that this partition of census tracts accurately represents neighborhoods as understood by landlords, tenants, and lenders.
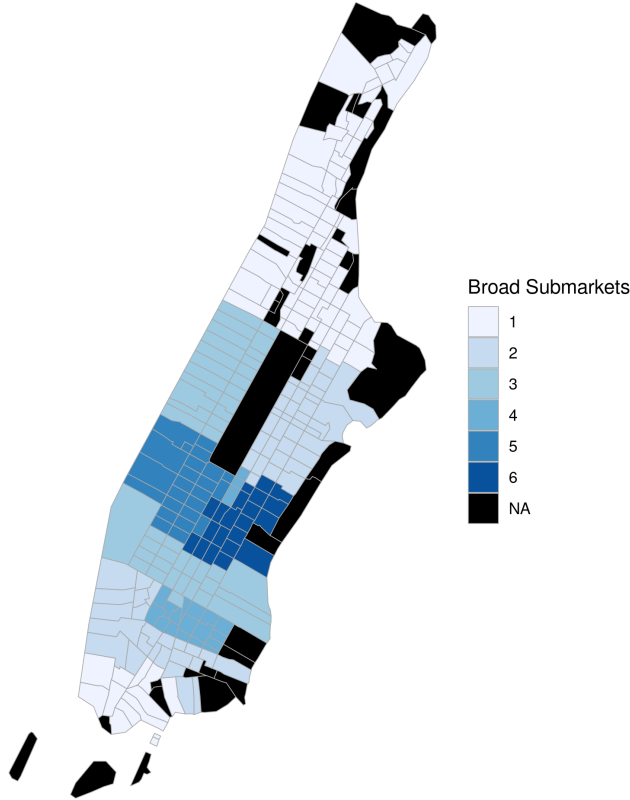

Figure 3: Submarkets

We define a space j as constrained by covenants in period t if j has an outstanding mortgage in t and market clearing rents in period t are below market clearing rents at the

time of last refinancing.

5   Descriptive evidence

To establish the empirical relevance of rent floors imposed by mortgage covenants for vacancies, we estimate a simple model of vacancy duration. On the left-hand-side, we have vacancy start and end dates at each storefront where vacancies or changes in tenants are ever observed. Storefronts that enter or exit the sample vacant have ambiguous vacancy durations, but this right censoring is straightforward to accommodate in estimation. On the right-hand-side of the regression, we have a measure of the bindingness of covenant restrictions, which we term the *rent gap*. Because the exact rent floors imposed by covenants are not directly observed, we must take a stance on how to measure covenants in the data. Ideally, we would be able to determine whether covenant rent-floors were binding at the storefront-level, by combining property-specific rent histories from CompStak, vacancy histories from Live.XYZ, and mortgage histories from ACRIS. However, because of the lack of cross-sectional coverage in CompStak, and the lack of time-series coverage in Live.XYZ, constructing a measure of covenant constraints at the storefront level is not possible for the majority of properties. Our solution proceeds in three parts. First, we divide Manhattan into geographic submarkets, and define the market-clearing rent in each submarket-quarter as the average rent per square foot of CompStak leases signed in that submarket-quarter. This gives us a measure of market rents today, even for storefronts that are not in CompStak. Second, we match mortgage histories to individual storefronts. We assume covenant-imposed rent floors reset every time mortgages are refinanced, and that properties without mortgages are not subject to covenants at all. Third, we follow the majority of covenants detected in our text data, and use a "market rent" definition of rent floors: in particular, we assume that a storefront is more constrained by covenants the further market rent today is below the market rent at the time of last refinancing. To be precise, we define the 'raw' rent gap as

$$rent\ gap = \{market\ rent\ at\ previous\ refinancing\ date\}/\{market\ rent\ today\}$$

High values for the rent gap indicate that market-clearing rents have fallen since a landlord last borrowed, making it likely that any rent-floors prescribed by mortgage covenants will now bind. Figure 4 plots average rent gaps against vacancy rates within the nine Manhattan submarkets. Within each submarket, the average rent gap is correlated with the level of vacancies over time, although the degree of correlation varies across locations. We transform the raw rent gap into a percentile, so that the maximum rent gap over the sample equals 1, the minimum rent gap (including the rent gap for any storefronts without outstanding mortgage balances) equals 0, the median rent gap equal 0.5, etc. This measure of covenant constraints varies at the storefront-quarter-mortgage-vintage level. We also include a series of controls, including the mortgage balance per square foot, the city-assessed value of the property, the number of units and number of floors in the building where the storefront is located, the lot size and shape, the amount of frontage, the retail area on the lot, the building age, whether the building is designated as a historical landmark, or is located in a historic district, whether the building is owned by an LLC, and whether the storefront is located in a building with special environmental requirements (a so-called "e-designation"). We also include fixed effects to control for the geographic submarket the storefront is located in, as well as the origination-year of the outstanding mortgage ("loan vintage"), and the year that the vacancy spell ended ("lease-out year").

Figure 4: Average rent gap vs. Vacancy rate, by Submarket
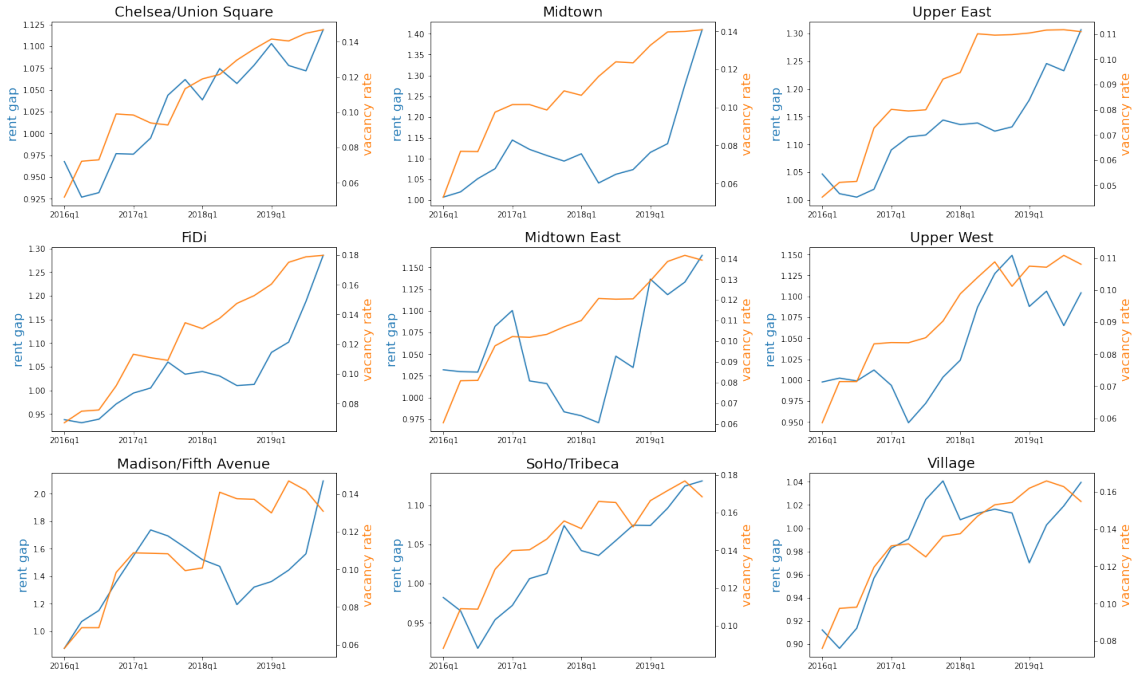
In all cases where our right-hand-side variables potentially change over time, we select the value of the variable in the period where the vacancy is filled (or in the final period of observation, if we do not see the vacancy filled at any point).

The results of the estimated proportional hazards model are displayed in Table 1. The negative coefficients on "rent gap" indicate that, relative to storefronts that are similar on observables, storefronts with relatively high "rent gaps" are less likely to exit vacancy, ie, less likely to be leased. Since rent gaps range between 0 and 1 by construction, the (exponentiated) coefficients can be interpreted as: "the relative reduction in the probability of leasing out, going from the least constrained storefront, to the most-constrained storefront". Exactly how much less likely depends on the specification, ranging from approximately 37% less likely, in the second specification, to around 83% less likely, in the second-to-last specification.

A few caveats are in order. First, covenants may be renegotiable outside of an actual refinancing event – landlords may approach their lenders and get approval for leases that nominal violate the covenants, or landlords may attempt to circumvent covenants without alerting their lenders. Especially if market rents have fallen a great deal since the last refinancing, landlords and banks should be able to agree to relax rent floors. Since we only observe the mortgage contracts, not any additional negotiations between landlords and banks, we cannot directly rule out these workarounds. Second, in our baseline regression, we treat all mortgages as potentially constraining, even if we do not detect covenants imposing rent-floors in the text of that particular mortgage. Our choice is driven by the fact that the OCR and NLP that we use to parse the text of the scanned mortgage documents is fairly error prone, and may not capture every instance of rent floor covenants. Not only that, but there may be additional covenants in the private loan agreement, including rent floors, that are not included in the publicly available mortgage agreement, which would remain undetectable even with perfect text parsing algorithms.

To explore the sensitivity of our results to these issues, we re-estimate the proportional

Table 1: Cox proportional hazards model for vacancy duration

| | *Dependent variable:* Vacancy duration | | | | |
	(1)	(2)	(3)	(4)	(5)
Rent gap	−0.527***	−0.456***	−0.510***	−1.726***	−1.671***
	(0.037)	(0.037)	(0.039)	(0.061)	(0.061)
Controls		X	X	X	X
Submarket fixed effects			X	X	X
Loan vintage fixed effects				X	X
Lease-out year fixed effects					X
Observations	10,933	10,546	10,401	10,401	10,401
R^2	0.018	0.036	0.045	0.120	0.230

Note: *p<0.1; **p<0.05; ***p<0.01

hazards model, first only counting storefronts as constrained when their mortgages are also part of a larger commercial mortgage backed security agreement (CMBS), and second, only considering a property as potentially constrained when we have successfully detected rent-floor covenants in that property's mortgage (Verified Covenant). It is impossible to renegotiate loan terms, including covenants, for an individual mortgage that has been securitized as part of a larger CMBS without permission from a (super)-majority of CMBS investors, and in some cases even asking to change the terms may itself automatically trigger a technical default, so a measure of the rent gap that only relies on mortgages that are part of CMBS agreements should be robust to the renegotiation concern. And while only using rent gaps from those properties where we actually detect rent-floor or leasing covenant language in the text should decrease our power and may introduce measurement error, results from such a measure are robust to the concern that our results are a false positive, driven by characteristics of storefronts with older outstanding mortgages that are unrelated to the presence of covenants.

The results of these robustness checks are displayed in Table 2. The first two columns display our baseline estimates, uncontrolled, and with all controls and fixed effects included. Columns (3) and (4) repeat this exercise, where now the rent gap measure is only constructed for properties whose mortgages are part of CMBS agreements (the rent gap is set to zero otherwise). Columns (5) and (6) repeat the exercise again, where rent gaps are only constructed for properties where we successfully detect covenants. The coefficients on the rent gap are meaningfully lower under both the CMBS and Verified Covenant specifications, suggesting that our first set of estimates may indeed have been biased upwards. However, the impact of binding covenants on leasing probabilities remains negative, highly statistically significant, and economically large, suggesting that those storefronts most constrained by covenants are between 22% and 29% less-likely to lease out, relative to observationally similar storefronts that are unconstrained.

Finally, our results are necessary limited to constraints imposed by first-lien mortgages, which as a matter of law must be recorded and made publicly available by the Office of

Table 2: Alternative rent gap specifications

| | Dependent variable: Vacancy duration | | | | | |
| | Baseline | | CMBS | | Verified Covenant | |
	(1)	(2)	(3)	(4)	(5)	(6)
Rent gap	−0.527***	−1.671***	−0.175**	−0.248***	−0.246***	−0.343***
	(0.037)	(0.061)	(0.082)	(0.086)	(0,0046)	(0.052)
Controls		X		X		X
Submarket fixed effects		X		X		X
Loan vintage fixed effects		X		X		X
Lease-out year fixed effects		X		X		X
Observations	10,933	10,401	10,933	10,401	10,933	10,401
R^2	0.018	0.230	0.0004	0.174	0.003	0.177

Note: *p<0.1; **p<0.05; ***p<0.01

the City Register, because the loans are secured by real property. For example, mezzanine debt is secured by an equity interest in the LLC that owns the property, as opposed to the real property itself, and therefore is not publicly recorded. Despite its importance in the actual functioning of the New York City real estate market, including an analysis of mezzanine debt is beyond the scope of this paper.

Despite these limitations, our empirical results in this section strongly suggest that mortgage covenants may play a role in prolonging vacancies.

6 Structural model

Similar to the stylized model outlined in the previous section, our structural model involves both landlords and banks making forward-looking, privately optimal decisions. Landlords make leasing and default decisions, taking prevailing market rents for their spaces, and bank mortgage lending policies as given, while banks make mortgage lending decisions, taking landlord leasing and default policies, and market rents for spaces as given. We do not model tenant entry or exit explicitly – a subject for future research. Instead, market rents and tenant separations from landlords are treated as exogenous processes. We outline both the landlord and the bank problems in greater detail below.

6.1 State variables

Retail spaces in the model are summarized by their current state $s = (\tilde{p}, p, p^f, \tilde{m}, \omega)$, which is a five-tuple consisting of the current rent roll (per square foot) $\tilde{p}$, market rent p, the covenant-induced rent floor p^f, the outstanding mortgage balance $\tilde{m}$, and the refinancing state ω. Our notational convention is that vacant retail spaces have $\tilde{p} = 0$, and retail spaces unencumbered by mortgages and covenants have $(p^f, \tilde{m}) = (0, 0)$. Rent roll $\tilde{p}$, rent floors

p^f, and mortgage balances $\tilde{m}$ are endogenous and persistent across periods, while market rents p are persistent, but evolve exogenously from the landlords' perspective (explained in greater detail below), and the refinancing state ω is exogenous and iid. State variables evolve according to a combination exogenous shocks and endogenous decisions landlords and banks.

6.2   Timing

Timing in the model is discrete, and the horizon is infinite. At the beginning of each period, demand, maturity, separation, and interest rate shocks η, ω, ζ, r^x are all realized. We denote the tuple of exogenous shocks with $\varepsilon = (\eta, \omega, \zeta, r^x)$. Landlords and banks observe demand, maturity, and separation shocks, while only banks observe the interest rate shock. Landlords with maturing mortgages ($\omega = 1$) must decide whether to pay off their existing mortgage balance $\tilde{m}$ and refinance at the new level being offered by banks, $m(s, r^x)$, or whether to default and exit. Landlords with a vacancy, either because they ended the prior period with a vacancy ($\tilde{p} = 0$), or because they separated from their previous tenant at the beginning of the current period ($\zeta = 1$), who do not default, or whose mortgages did not mature in the first place, observe the market rent for their space p, and decide whether or not to lease out or continue with a vacancy. After the exogenous shocks to the state ε are revealed, but before decisions are made, landlords are also subject to iid T1EV preference shocks $\epsilon = (\epsilon^\ell, \epsilon^d)$, which enter into the leasing and default choices in the usual way. In the case where both default and leasing decisions need to be made, the default shock ϵ^d is realized first, and the landlord must make a default decision taking expectations over the value of the leasing shock ϵ^ℓ. Finally, all landlords with an occupied space collect rents from their tenants and make their debt service and tax payments.

6.3   Landlords

Landlords are risk-neutral, infinitely lived, and make leasing, borrowing, and default decisions. Each landlord is associated with exactly one retail space, indexed by $j = 1, \ldots, J$, so we may refer to landlord j or space j interchangeably. Any individual landlord who has not defaulted on his mortgage is in the same state s as his corresponding retail space. Landlords' believe future market rents p evolve according to a known parametric model $F_p(\theta)$, where the belief parameters θ may be j-specific (explained in more detail below), and all the influence of aggregate variables on landlord payoffs and decisions comes through the belief parameters θ, ie, the nature of the stochastic process governing market rents. Although θ may be j specific, in this section we omit j subscripts for the sake of notational clarity. Finally, we append a "default state indicator" D to the end of the landlord's state vector for technical reasons (note that the values of the state variables are irrelevant to the landlord in default, because all landlords immediate receive a terminal payout of zero and exit following a default decision).

Landlords flow payoffs are determined by rents $\tilde{p}$ less debt-service payments $r^m \cdot \tilde{m}$ and taxes τ. We denote the landlord's leasing and default decisions as $\ell(s) \in [0, 1] \mid s$ and $d(s) \in [0, 1] \mid s$, respectively, and the bank's lending decision as $m(s) \geq 0 \mid s$. Flow payoffs are denoted $\mathcal{R}(s)$ and are given by

$$\mathcal{R}(s) = \begin{cases} (\tilde{p} - r^m \cdot \tilde{m}) \cdot (1 - \tau) \\ \qquad\qquad\qquad\qquad\qquad\qquad \text{if } \tilde{p} > 0 \text{ and } \omega = 0 \\ (1 - d(s)) \cdot \mathbb{E}_{r^x}\left[m(s, r^x) - \tilde{m} + (\tilde{p} - r^m \cdot m(s, r^x)) \cdot (1 - \tau)\right] \\ \qquad\qquad\qquad\qquad\qquad\qquad \text{if } \tilde{p} > 0 \text{ and } \omega = 1 \\ \ell(s) \cdot \left(p \cdot (1 - \tau) - \lambda \cdot \tilde{m} \cdot \kappa(s) - c^L\right) - r^m \cdot \tilde{m} \cdot (1 - \tau) \\ \qquad\qquad\qquad\qquad\qquad\qquad \text{if } \tilde{p} = 0 \text{ and } \omega = 0 \\ (1 - d(s)) \cdot \mathbb{E}_{r^x}\left(m(s, r^x) - \tilde{m} + \ell(\hat{s}) \cdot (p \cdot (1 - \tau) - c^L) - r^m \cdot m(s, r^x) \cdot (1 - \tau)\right) \\ \qquad\qquad\qquad\qquad\qquad\qquad \text{if } \tilde{p} = 0 \text{ and } \omega = 1 \end{cases}$$

where

$$\hat{s} = (0, p, p, m(s, r^x), 0)$$

In the simplest case, a landlord with a rented-out space and an outstanding mortgage ($\tilde{p} > 0$, $\omega = 0$) collects rent $\tilde{p}$, makes debt service payments $r^m \cdot \tilde{m}$, and pays taxes τ on the difference. For a landlord with a rented-out space whose loan matures ($\omega = 1$) and decides to refinance ($d(s) = 0$), flow payoffs consist of the equity extraction or injection due to the difference between the new and old mortgage balances $m(s, r^x) - \tilde{m}$, as well as rents $\tilde{p}$, debt-service on the new debt balance $r^m \cdot m(s, r^x)$, and tax payments. When a landlord has a vacancy and an outstanding mortgage ($\tilde{p} = 0$, $\omega = 0$), the landlord must first decided whether or not to lease the space out ($\ell(s) = 1$); then, if he does lease the space, he earns the market rent p, pays a fixed cost for marketing the space c^L, and also pays a cost proportional to his outstanding mortgage balance ($\lambda \cdot \tilde{m}$) for violating any binding covenants written into the mortgage ($\kappa(s) = \mathbf{1}\{p < p^f\}$). If the landlord opts not to rent the space ($\ell(s) = 0$), he earns zero rent and does not incur any leasing costs; in either case, he must make his debt service and tax payments. Finally, when a landlord has a vacancy and a mortgage that matures ($\tilde{p} = 0$, $\omega = 1$), the landlord must first decide whether to default or refinance, and then, if he refinances, must make a vacancy-filling decision. Note that by construction, landlords cannot violate rent-floor covenants in the same period that they refinance, since the rent-floor specified by the covenant is equal to the market rent at the time of refinancing. In all cases, landlords that default ($d(s) = 1$) are assumed to receive flow payoffs (and continuation values) of zero, and exit.

Landlord value and policy functions: As mentioned above, the landlord makes two binary decisions, to lease or stay vacant ($\ell(s)$) and to default or refinance ($d(s)$). The timing of these decisions is exogenous, in the sense that new vacancies only arise through exogenous separations ($\zeta = 1$), and mortgages only mature stochastically ($\omega = 1$), but the persistence of vacancies and the frequency of defaults are both endogenous, since landlords may choose not to fill the vacancy immediately, or may refinance, even at significant cost, if continuation values are high enough. Unlike vacancies, the decision to either refinance or default must be made immediately. In both cases, the landlord's policy maximizes the sum of his flow payoff today, and his discounted expected continuation value. The landlord's Bellman equation is

$$V(s) = \max_{\ell(s) \in [0,1], d(s) \in [0,1]} \mathcal{R}(s) + \beta \mathbb{E}[V(s') \mid s]$$

The leasing and default policy functions are those decisions that maximize the landlord's expected value at every state

$$\ell(s, \epsilon^\ell) = \arg\max_{\ell \in \{0,1\}} \left\{ (1-\ell) \cdot \left(V^V(s) + \epsilon_0^\ell\right) + \ell \cdot \left(V^L(s) + \epsilon_1^\ell\right) \right\}$$

$$\ell(s) = \mathbb{E}_{\epsilon^\ell}[\ell(s, \epsilon^\ell)] = \frac{\exp(V^L(s)/\sigma_\ell)}{\exp(V^L(s)/\sigma_\ell) + \exp(V^V(s)/\sigma_\ell)}$$

$$V^L(s) = (p - r^m \cdot \tilde{m}) \cdot (1-\tau) - c^L - \lambda \cdot \tilde{m} \cdot \kappa(s) + \beta\mathbb{E}[V(s') \mid (p, p, p^f, \tilde{m})]$$

$$V^V(s) = (-r^m \cdot \tilde{m}) \cdot (1-\tau) + \beta\mathbb{E}[V(s') \mid (0, p, p^f, \tilde{m})]$$

$$d(s, \epsilon^d, r^x, \epsilon^\ell) = \arg\max_{d \in \{0,1\}} \left\{ d \cdot \epsilon_0^d + (1-d) \cdot \left(V^R(s) + \epsilon_1^d\right) \right\}$$

$$d(s) = \mathbb{E}_{\epsilon^d, r^x, \epsilon^\ell}[d(s, \epsilon^d, r^x, \epsilon^\ell)] = \frac{\exp(V^R(s)/\sigma_d)}{1 + \exp(V^R(s)/\sigma_d)}$$

$$V^R(s) = \begin{cases} \mathbb{E}_{r^x}[m(s, r^x) - \tilde{m} + (\tilde{p} - r^m \cdot m(s, r^x)) \cdot (1-\tau) + \\ \beta\mathbb{E}[V(s' \mid (\tilde{p}, p, p, m(s, r^x)))]] & \text{if } \tilde{p} > 0 \\ \mathbb{E}_{r^x}[m(s, r^x) - \tilde{m} + \ell(\hat{s}) \cdot (p \cdot (1-\tau) - c^L) - r^m \cdot m(s, r^x) \cdot (1-\tau) + \\ \beta\mathbb{E}[V(s') \mid (\ell(\hat{s}) \cdot p, p, p, m(s, r^x)))]] & \text{if } \tilde{p} = 0 \end{cases}$$

$$\hat{s} = (0, p, p, m(s, r^x), 0)$$

Note that both leasing and defaut decisions can be written as a function of just three state variables, $\ell(s) \equiv \ell(p, p^f, \tilde{m})$, since leasing is only possible when $\tilde{p} = 0$, and likewise, $d(s) \equiv d(\tilde{p}, p, \tilde{m})$, since refinancing always resets covenant-induced rent floors p^f to current market rents p.

6.4 Banks

Banks are deep-pocketed, risk-neutral, and infinitely-lived. Each period, they can either make commercial mortgage loans, which are long-term, interest-only loans that stochastically expire at a rate ϕ, and which pay a constant, exogenous coupon rate r^m each period until expiry, or earn a one-period, stochastic risk-free return $r^x \sim F_x$. The expected value of a mortgage of size m secured by a property in state s is given by the value at origination:

$$B^o(m, s) = (1 - d(s)) \cdot (r^m \cdot m + \beta\mathbb{E}[B(s') \mid (m, s)]) + d(s) \cdot m - \frac{\gamma}{2} \cdot m^2$$

$$= B(\hat{s}) - d(s) \cdot (m - B(\hat{s})) - \frac{\gamma}{2} \cdot m^2$$

$$B(s) = (1 - \omega) \cdot (r^m \cdot \tilde{m} + \beta\mathbb{E}[B(s') \mid s]) + \omega \cdot B^T(s)$$

$$B^T(s) = (1 - d(s)) \cdot \tilde{m} + d(s) \cdot \psi \cdot W(s)$$

$$W(s) = V(\tilde{p}, p, p, 0, 0)$$

$$\hat{s} = (\tilde{p}, p, p, m, 0)$$

The value of the mortgage at origination, B^o is the sum of income from debt service today $r^m \cdot m$, and the discounted value of the mortgagee tomorrow, $B(s')$, less the cost of mortgage origination, which is quadratic in m. If the landlord refuses the banks' mortgage offer of

m and defaults, the bank keeps its m dollars, but still incurs the mortgage origination cost $\frac{\gamma}{2}m^2$. Since all mortgages are interest-only, with the whole principal repaid as a balloon when the loan matures, the outstanding balance tomorrow (and in every future period until maturity), is equal to the origination balance today ($\tilde{m}' = m$). In every period after origination, if there is no maturity shock ($\omega = 0$), the borrow continues to make debt-service payments $r^m \cdot \tilde{m}$, while if there is a maturity shock ($\omega = 1$), if the landlord repays ($d(s) = 0$), the bank will receive the principal $\tilde{m}$ or, if the landlord defaults ($d(s) = 1$), the bank will take possession of the property, which it values at $\psi W(s)$. The value of the property to the bank is the product of two factors: the market price of the property $W(s)$, and the exogenous short-sale discount $\psi \in (0, 1)$. The final equality follows from the fact that, from the landlord's perspective, buying a property unencumbered by a mortgage (because the mortgage ceases to exist after default) is equivalent to refinancing a property with a mortgage balance of zero. Therefore, assuming free entry of landlords, the market price of the property will be bid up to the landlord's value $V(\tilde{p}, p, p, 0, 0)$.

We define the per-dollar return on mortgage lending as

$$b_0(m, s) \equiv \frac{B^o(m, s) - m}{m}$$
$$= (1 - d(s)) \cdot \frac{(B(\hat{s}) - m)}{m} - \frac{\gamma}{2} \cdot m$$

To be willing to lend, the value of originating a mortgage of size $m > 0$ must weakly exceed the return associated with investing m in the bank's outside option, $b^o(m, s) \geq r^x$. The return on mortgage lending, $b_0(m, s)$ is weakly decreasing in the loan size m. Furthermore, we assume that the banking sector is perfectly competitive, so banks are held to their participation constraint, and $b^o(m, s) = r^x$. Because $b_0(m, s)$ is decreasing in loan size, we can invert it to arrive at the bank's mortgage lending policy function

$$m(s, r_x) = b_0^{-1}(s, r^x)$$

From the landlord's perspective, the bank's outside option r^x is private information. However, the distribution of r^x is common knowledge to banks and landlords. Therefore, the landlord views the bank's mortgage lending policy function as conditionally stochastic as well, with conditional CDF

$$F_m(m \mid s) = F_x(b_0(m, s))$$

In Section 7 , we assume that $r^x \sim N(\mu_{r_x}, \sigma_{r_x})$.

7 Structural estimation

To estimate the parameters of the structural model, we proceed in four steps. First we regress observed rents on storefront, building, and neighborhood characteristics, to isolate the component of rents that is time-varying. We then regress this time-varying component on its lags, to obtain an approximation of landlord beliefs about market rent dynamics. Second, we regress observed mortgage origination amounts on the storefront state (rent roll, market rent, and existing mortgage balance) to obtain a reduced-form estimate of the banks' mortgage lending policy function. Third, taking estimated market rent dynamics

Table 3: Estimated AR(1) parameters for log market rents

ρ_p	μ_p	σ_p
0.799	3.86	0.0764

and observed bank lending behavior as given, we estimate the landlords' structural parameters by generalized method of moments. Finally, taking estimated market rent dynamics, observed bank lending decisions, and landlords' structural parameters (and corresponding policy functions) as given, we estimate banks' structural parameters by minimum distance.

7.1 Rent dynamics and landlord beliefs

We start with our repeated cross section of leases. We model the log rent per square foot as a partially linear function of lease-level observables.

$$\log p_{j(\ell),t(\ell)} = x'_{j(\ell)}\alpha + \gamma(lat_{j(\ell)}, long_{j(\ell)}, t(\ell)) + \eta_\ell$$

where x includes characteristics such as the building age, total square-footage, and indicators for local zoning, whether the storefront is on an avenue or a side-street, and whether the storefront lies on a major commercial corridor. The function γ is estimated nonparametrically to flexibly and smoothly capture variation in rents by location (latitude and longitude) and over time. We think of this specification as an alternative to a regression with time period and neighborhood fixed effects, one which allows us to capture different price dynamics at each location. Notice that, although we observe leases in different time periods, we only rarely observe two different leases at the same storefront, hence the dependence of location j and time t on the lease ℓ.

Given estimates $\hat{\alpha}, \hat{\gamma}(\cdot), \hat{\eta}$, we can predict the log market rent at any time and at any location

$$\hat{\log}p_{j,t}(x_j, lat_j, long_j, t) = x'_j\hat{\alpha} + \hat{\gamma}(lat_j, long_j, t) + \hat{\eta}_j$$

Finally, we approximate the dynamics contained in the $\hat{\gamma}$ function with an AR(1), estimated at the storefront-level:

$$\hat{\log}p_{j,t} = \mu_j + \rho_j\hat{\log}p_{j,t-1} + \sigma_j\epsilon_{j,t}$$

We assume that landlords treat market rents at their storefront as evolving exogenously, and they are endowed with knowledge of their location-specific AR(1) parameters $(\mu_j, \rho_j, \sigma_j)$, which they use to form their conditional expectations of market rents tomorrow.

While our notation and our estimation strategy is general enough to accommodate very rich storefront-level market rent dynamics, in practice this level of heterogeneity makes estimation of the structural model extremely computationally expensive. Therefore, for now, we treat market rent dynamics as homogenous across storefronts, with the γ function above simplifying to a time-series of estimated time fixed effects.

Table 4: Grid values

Market rent $p^\dagger$		25.77		34.97		47.47		64.42		87.43	
Mortgage balance $\tilde{m}^\dagger$	0	100	200	300	400	500	600	700	800	900	1000+

7.2 Discretizing the state space

To actually solve and estimate the model, we must choose a discrete set of grid points for our continuous state variables, summarized in Table 4. We denote the discretized state with the superscript $s^\dagger$, so rents, market rents, rent floors, mortgage balances, and refinancing shocks are denoted, $\tilde{p}^\dagger, p^\dagger, p^{f\dagger}, \tilde{m}^\dagger$, and $\omega^\dagger$. The set of grid points for rent rolls $\tilde{p}^\dagger$ and rent floors $p^{f\dagger}$ is identical to the grid points for market rents $p^\dagger$, with a zero appended to the front, representing vacancy for the rent roll state, and the absence of covenants for the rent floor state.

To discretize the state space, we first generate a grid for log market rents using the Rouwenhorst method for discretizing AR(1) processes (Kopecky Suen 2010). Observed log market rents are assigned to the state associated with the grid point closest to their observed value (in log space), then exponentiated. Importantly, storefronts with rents that fall significantly outside of this range are not used directly in estimation.. Storefronts without an outstanding mortgage are assigned $\tilde{m}^\dagger = 0$, while storefronts with greater than zero and less than or equal to \$150 psf of mortgage balance outstanding are assigned to $\tilde{m}^\dagger = 100$, greater than \$150 psf and less than or equal to \$250 psf are assigned to $\tilde{m}^\dagger = 200$, etc., and spaces with greater than \$950 psf of mortgage balance outstanding are assigned to $\tilde{m}^\dagger = 1000$. The refinancing state is inferred from the observed change in mortgage balances: for a given storefront, if $\tilde{m} \neq \tilde{m}'$, then we infer that $\omega^\dagger = 1$, otherwise, we assume $\omega^\dagger = 0$.

7.3 Reduced form bank lending policy functions

In our second step, we regress observed mortgage balances (per square foot) at origination on observed rent rolls, market rents, and pre-existing mortgage balances. This gives us a reduced form mortgage policy function, $\hat{g}_B$, that we plug-in as the banks' policy rule in the third estimation step. To estimate the reduced form mortgage policy function, we use the discretized state variables and estimate an ordered probit, regressing the new mortgage balance $\tilde{m}^\dagger_{j,t+1}$ on the current rent roll $\tilde{p}^\dagger_{j,t}$, current market rent $p^\dagger_{j,t}$, the current mortgage balance $\tilde{m}^\dagger_{j,t}$, and all their two- and three-way interactions.

$$
\begin{aligned}
m^\dagger_{j,t+1} = {} & \alpha_0 + \alpha_1 \cdot \tilde{p}^\dagger_{j,t} + \alpha_2 \cdot p^\dagger_{j,t} + \alpha_3 \cdot \tilde{m}^\dagger_{j,t} \\
& + \alpha_4 \cdot \tilde{p}^\dagger_{j,t} \times p^\dagger_{j,t} + \alpha_5 \cdot \tilde{p}^\dagger_{j,t} \times \tilde{m}^\dagger_{j,t} + \alpha_6 \cdot p^\dagger_{j,t} \times \tilde{m}^\dagger_{j,t} \\
& + \alpha_7 \cdot \tilde{p}^\dagger_{j,t} \times p^\dagger_{j,t} \times \tilde{m}^\dagger_{j,t} + \varepsilon_{j,t+1}
\end{aligned}
$$

7.4 Landlord parameters

Taking our estimates processes for rent dynamics and bank lending policies as given, we can estimate the remaining landlord parameters by generalized method of moments. Our

Table 5: Reduced form bank parameter estimates

	Dependent variable:
	$\tilde{m}'$
$\tilde{p}$	−0.276
	(0.190)
p	−0.347
	(0.258)
$\tilde{m}$	0.388**
	(0.173)
$\tilde{p} \times p$	0.144*
	(0.081)
$\tilde{p} \times \tilde{m}$	0.181**
	(0.077)
$p \times \tilde{m}$	0.291***
	(0.098)
$\tilde{p} \times p \times \tilde{m}$	−0.100***
	(0.031)
Observations	1,367
Note:	*p<0.1; **p<0.05; ***p<0.01

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targeted moments consisted of the aggregate vacancy rates in each quarter, as well as the score of the conditional log likelihood implied by the structural model. We denote the landlord's parameters $\theta_L = (\beta, \delta, \phi, c^L, \lambda, \tau, \sigma^\ell, \sigma^d)$, which correspond to the discount rate, the survival probability of a lease, the survival probability of a mortgage loan, the fixed cost of leasing, the cost of violating covenants, and the variances of the Type 1 Extreme Value shocks for leasing and defaulting, respectively. For now, we calibrate β, τ, σ^ℓ, and σ^d, and estimate δ, ϕ, c^L and λ. Given a guess of θ_L, we then solve the landlord's problem by policy function iteration. In the course of solving the landlords' problem, we generate a state transition matrix, which we then use to evaluate the probability of the sequence of state transitions that we observe in our data.

Consider an individual space j, where we observe T_j quarters of data, and denote the sequence of observed states at that space $x_j = \{x_{j,t}\}_{t=0}^{T_j}$, where $x_{j,t} \in \{s_{i1}, \dots, S_{iN}\}$ for every t. Let $\theta_j = [(\mu_j, \rho_j, \sigma_j) ; \hat{g}_B ; \theta_L]$ denote the collection of the belief parameters, reduced form bank parameters, and landlord parameters (at location j). The conditional likelihood of a particular sequence x_j under θ_j is

$$\mathcal{L}(x_j, \theta_j) = \prod_{t=0}^{T_j} f(x_{j,t} \mid x_{j,t-1} ; \theta_j)$$

$$= \prod_{t=0}^{T_j} \mathbb{P}(x_{j,t} = s' \mid x_{j,t-1} = s ; \theta_j)$$

$$= \prod_{t=0}^{T_j} \mathcal{T}_{\iota(x_{j,t}), \iota(x_{j,t-1})}(\theta_j)$$

where $\iota : \{s_{i1}, \dots, s_{iN}\} \to \{1, \dots, N\}$ maps state values to their indices, so $\mathcal{T}_{\iota(x_{j,t}), \iota(x_{j,t-1})}(\theta_j)$ is the $(\iota(x_{j,t}), \iota(x_{j,t-1}))^{th}$ entry in the state transition matrix $\mathcal{T}$. Analogously, the conditional likelihood of the entire dataset under the model is

$$\mathcal{L}(x, \theta) = \prod_{j=0}^{J} \prod_{t=0}^{T_j} \mathcal{T}_{\iota(x_{j,t}), \iota(x_{j,t-1})}(\theta_j)$$

Notice that our setup is flexible enough to accommodate different beliefs about rent dynamics at each location j, while still imposing common landlord and bank parameters across all locations. In practice, we assume that market rent dynamics at every storefront are driven by changes in a common factor (estimated in subsection 1 above). Our first set of moments are the derivatives (with respect to landlord parameters) of the log of the conditional likelihood above

$$\mathcal{S}(x, \theta_L) = \frac{\partial \log \mathcal{L}(x, \theta_L)}{\partial \theta_L}$$

We are particularly in matching the overall level of vacancies in our full sample. Therefore, we also compute the aggregate vacancy rate implied by the model at a guess of landlord parameters, and compare it to the observed vacancy rate in the data, quarter by quarter. Let $A \subset \{s_1, \dots, s_N\}$ denote the set of states where storefronts are vacant ($\tilde{p} = 0$), and let

Table 6: Landlord parameter estimates

Parameter	Value	Standard Error	Estimated / Calibrated
λ	1.447	.	Estimated
c^L	153	.	Estimated
δ	0.973	.	Estimated
ϕ	0.965	.	Estimated
β	0.978	.	Calibrated
r^m	0.027	.	Calibrated
τ	0.30	.	Calibrated
σ_ℓ	150	.	Calibrated
σ_d	150	.	Calibrated

J_t denote the number of storefronts that we observe in quarter t. Then, stacking across time periods t, our vacancy moments are

$$\mathcal{V}(x, \theta_L) = \sum_{j=0}^{J_t} \frac{\mathbf{1}\{x_j \in A\}}{J_t} - \sum_{j=0}^{J_t} \ell(x_j \; ; \theta_L)$$

Given these sets of moments $\mathcal{S}(x, \theta_L)$ and $\mathcal{V}(x, \theta_L)$, denote the collection of all landlord moments as $\mathcal{H}(x, \theta_L) = [\mathcal{S}(x, \theta_L), \mathcal{V}(x, \theta_L)]$, and choose θ_L to solve

$$\min_{\theta_L} \mathcal{H}(x, \theta_L)' \Omega \mathcal{H}(x, \theta_L)$$

for some weight matrix Ω, which we design to give relatively equal weight to the scores and the vacancy moments. The results of the GMM estimation are presented in Table 6. Covenants penalties λ are estimated to be equal to roughly \$1.45 per dollar of mortgage balance outstanding per square foot, whereas the fixed cost of leasing is estimated to be equal to \$153 per square foot, a bit more than the equivalent of three quarters' worth of rent at the average market rent. Our estimated value of $\delta = .973$ implies an average lease duration of 9.26 years, which is quite close to the modal 10 year lease length that we observe in the CompStak data. Our estimated value of $\phi = 0.965$ implies an average mortgage duration of 7.14 years.

7.5   Bank parameters and simultaneous estimation

In principle, we could estimate bank and landlord parameters simultaneously. However, solving the two sets of agents' problems simultaneously is prohibitively slow for estimation, which is why we adopt the approach outlined above. However, for counterfactuals, reduced form estimates of banks' lending policy function are insufficient: we need estimates of the bank structural parameters. Given the landlord's parameters θ_L, and a guess at bank parameters $\theta_B = [\psi, \mu_{r_x}, \sigma_{r_x}, \gamma]$, we choose θ_B to minimize the distance between observed and model-implied policy functions

$$\min_{\theta_B} (\hat{g}_B - g(\theta_B)) W (\hat{g}_B - g(\theta_B))$$

Table 7: Bank parameter estimates

Parameter	Value	Standard Error	Estimated / Calibrated
ψ	0.8122	.	Estimated
μ_{rx}	.0645	.	Estimated
σ_{rx}	.022	.	Estimated
γ	5e-5	.	Estimated
β	0.978	.	Calibrated
r^m	0.027	.	Calibrated

where W is some weight matrix (we choose the identity matrix).

8 Counterfactuals

In this section, we assess the quantitative impact of leasing covenants on vacancy rates and mortgage origination volume over our sample period. In our first counterfactual experiment, we set the penalty on covenant violations, λ, to zero, effectively abolishing covenants, and simulate state transitions for our panel of storefronts over the 2016 to 2020 period. In our second counterfactual, we return λ to its estimated level, and instead set the fixed cost of leasing c^L to half its estimated value, and again, simulate state transitions for our storefronts over the 2016 to 2020 period. We then compare the relative reduction in vacancies across counterfactual scenarios to assess the relative importance of covenants in particular, as a force for prolonging vacancies. Finally, we simulate long counterfactual histories under the three different parameter configurations (at estimated parameters, setting $\lambda = 0$, and setting $c^L = \hat{c}^L/2$) to capture any steady-state changes in leasing and lending behavior.

8.1 Exogenous rents, endogenous vacancies

Our primary research question is whether, in the absence of covenant-induced rent floors, vacancies would have differed significantly over our sample period. To answer this question, we need to take a stand on the evolution of exogenous shocks, namely, tenant separations ζ, market rent shocks η, and mortgage maturity ω. While the ideal counterfactual procedure would endogenize market rents (as well as separations and mortgage durations), that is currently beyond the scope of our paper. Instead, we fix all shocks taken to be exogenous by landlords (ζ, η, ω), and simulate landlords' and banks' endogenous counterfactual decisions in response to the same shocks that were present over the sample period.

The first step in calculating the counterfactual is re-solving the landlords' problem at new, counterfactual parameter values, taking the banks' estimated mortgage lending policy function, as well as all exogenous shocks, as given. This object is valuable by itself, since it allows us to simulate a counterfactual scenario where only the landlords are allowed to adjust their behavior. In the second step, we re-solve the banks' problem, taking the landlords' new leasing and default policies as given. We iterate on steps 1 and 2 until convergence (in both landlord and bank values), yielding the leasing, default, and mortgage lending policy functions that we will use in our benchmark counterfactual simulations. Recall that each policy function is a probability distribution (over $\{0, 1\}$ in the case of leasing and default decisions, and over $\{0, 100, 200, \ldots, 1000\}$ in the case of mortgage

lending decisions) conditional on the state, so landlord and bank decisions are random to a significant degree. To reduce the role of stochastic noise in our counterfactual results, we simulate 20 counterfactual histories for each storefront in our sample, and then average across histories, within storefronts (for the aggregate results, we average across storefronts as well). Within a given storefront, the exogenous shocks are the same across the 20 counterfactual histories; however, the endogeous decisions, and therefore, the evolution of the state, will differ. In other words, at the storefront-level, we only average over the particular realizations of iid preference shocks, $\epsilon^\ell, \epsilon^d, r^x$, whereas, when we average across storefronts, we also average over separation, market rent, and maturity shocks, ζ, η, ω.

Finally, for internal consistency, all counterfactual comparisons are made relative to our 'baseline counterfactual', where we simulate endogenous bank and landlord decisions and storefront state transitions at estimated, as opposed to counterfactual, parameters. Comparisons of counterfactual vacancies and mortgage originations to observed vacancy rates and mortgage origination volumes are included in the Appendix, for completeness.

8.2   Counterfactual Results

Several authors have draw attention to New York City's extensive land use regulations as a possible contributor to persistent storefront vacancies. Moreover, even in the absence of significant regulatory burdens, the costs associated with signing up a new tenant may be substantial, from fees paid to brokers and other intermediaries, which we lack data on to the direct costs of renovations, and incentives provided to tenants upfront. Recall that in Section 5, we documented that landlords offer tenant improvements and months of free rent valued at up to 10% all the rental income totaled over the life of the lease. By comparison, rent-floors induced by mortgage covenants seem rather esoteric. Therefore, as a way to quantify the relative importance of covenants for vacancies, we consider the impact of reducing the fixed cost of leasing by 50%, which we think of as a reasonable upper bound for the cost-reductions that might be achieved through various regulatory reforms. As it turns out, covenant restrictions appear to be quite important quantitatively, relative to this benchmark.

8.2.1   Counterfactual vacancies: $2016 - 2020$

Figure 5 displays the results of the counterfactual comparisons described above. Vacancies increase across all counterfactual scenarios, but cumulative vacancies are 11.4% lower (about 1.5 percentage points) in 2020 in the counterfactual where we eliminate penalties for violating covenants, compared to the baseline. Furthermore, this 12% reduction is substantially larger than what can be achieved by lowering leasing costs. Compared to eliminating covenants, reducing the fixed cost of leasing by 50% only reduces the vacancy rate by 2.7% (about 0.37 percentage points), which is four times less than the effect of eliminating covenants.

These results suggest that the change in vacancy rates from eliminating covenants may be substantial. However, as outlined in Section 3, rent-floors created by covenants potentially play an important role in reducing agency frictions between landlords and banks, and eliminating them may well cause increased risk-taking by landlords, leading banks to respond in turn by reducing credit supply. In the next subsection, we examine whether this concern about a reduction in credit supply is warranted.

Figure 5: Counterfactual vacancy rates
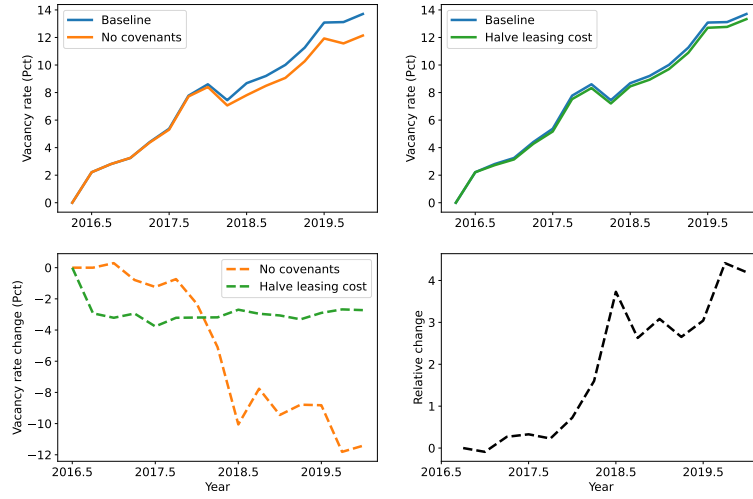
The top-left subfigure plots the trajectory of the aggregate vacancy rate (in percentage points) at baseline (blue, solid), and in a counterfactual scenario where covenants are not enforced, $\lambda = 0$ (orange, solid). The top-right subfigure plots the trajectory of the aggregate vacancy rate (in percentage points) at baseline (blue, solid), and in a counterfactual scenario where the fixed cost of leasing is reduced by 50%, $c^L = 75$ (green, solid). The bottom-left subfigure plots the percentage change in vacancy rates under the no-covenants (blue, dotted) and low fixed cost (orange, dotted) scenarios. The bottom-right subfigure plots the relative reduction in vacancies in the no-covenants vs. low fixed cost counterfactuals, so the black dotted line is equal to the blue dotted line divided by the orange dotted line.

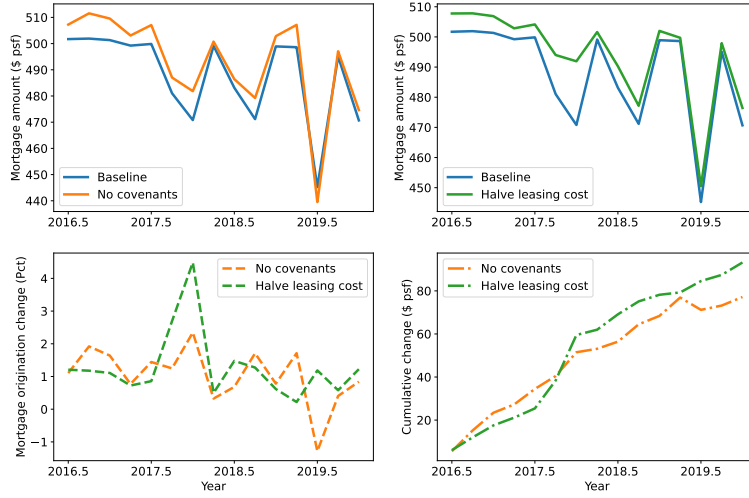### 8.2.2 Counterfactual mortgage originations: 2016 − 2020

Figure 6 displays the average mortgage origination volume (in dollars per square foot) under our baseline and our two counterfactual scenarios. The actual number of mortgage originations does not change across counterfactual scenarios, as the mortgage maturity / refinancing shocks ω are exogenous and common across counterfactual scenarios, and in every case, landlords choose to accept the banks' mortgage offers, rather than default. Therefore, the relevant measure of credit supply is the average dollar amount originated. Perhaps surprisingly, the elimination of covenants and the reduction of fixed leasing costs both result in larger mortgages being originated on average, although the changes are small. The intuition for the fixed cost counterfactual is straightforward: though the fixed cost of leasing does not play a direct role in lending and default decisions, lowering the fixed cost of leasing raises landlords' continuation values across all states, making default less likely overall, which results in banks being willing to originate larger mortgages. In fact, the intuition for the reduction-in-fixed-costs counterfactual holds for the elimination-of-covenant-penalties counterfactual as well: covenants reduce landlords' values both directly, by forcing them to either forgo rental income, or pay a penalty, when they are constrained, and indirectly, through the risk that landlords will become constrained at some future point when they separate from their tenants and market rents have fallen. This increases landlords tendency to default in exactly the same way that increasing the fixed cost would, by lowering landlords' continuation values across all states. In principle, this increased default risk might be tolerable, or even preferable, from the banks' perspective, if it meant that losses in default were limited. However, it is evident that in these counterfactuals, the first force dominates.

8.2.3 Inspecting the mechanism

8.2.4 Simulated steady state

9   Conclusion

Figure 6: Counterfactual mortgage originations

The top-left subfigure plots the trajectory of the average mortgage origination volume (in dollars per square foot) at baseline (blue, solid), and in a counterfactual scenario where covenants are not enforced, $\lambda = 0$ (orange, solid). The top-right subfigure plots the trajectory of the average mortgage origination volume (in percentage points) at baseline (blue, solid), and in a counterfactual scenario where the fixed cost of leasing is reduced by 50%, $c^L = 75$ (green, solid). The bottom-left subfigure plots the percentage change in origination volume under the no-covenants (blue, dotted) and low fixed cost (orange, dotted) scenarios. The bottom-right subfigure plots the cumulative change in average mortgage origination amounts (in dollars per square foot) over the sample in the no-covenants (orange, dash-dotted) and low fixed cost (green, dash-dotted) counterfactuals.

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