Insurers Monitor Shocks to Collateral: Micro Evidence from Mortgage-backed Securities*

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March 4, 2024

Abstract

This paper uncovers if and how insurance companies react to shocks to collateral in their portfolio of securitized assets. We address this question in the context of commercial real estate (CRE) cash flow shocks, which are informationally opaque to holders of commercial mortgage-backed securities (CMBS). Using detailed micro data, we show that cash flow shocks caused by lease expiration cause CRE mortgage delinquency and especially so for offices after the COVID-19 pandemic, reflecting lower demand for these properties. Insurers react to such cash flow shocks by selling more exposed bonds, and the composition of their CMBS portfolio affects their trading behavior in other assets. Our results indicate that institutional investors actively monitor underlying asset risk, and highlight the role played by cash flow shocks in CRE lending.

JEL codes: G20, G21

Keywords: Insurance Sector, Risk Management, Mortgage Default, Commercial Real Estate, CMBS, Work-from-home

*Saidi acknowledges funding by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy (EXC 2126/1 – 390838866) and through CRC TR 224 (Project C03). Fetzer acknowledges funding by the Leverhulme Prize in Economics, a European Research Council Starting Grant (ERC, MEGEO, 101042703), and Deutsche Forschungsgemeinschaft (DFG, EXC 2126/1 – 390838866). The paper represents the authors' personal opinions and not necessarily the views of the Bank of England.

1. Introduction

Loans that use real estate as collateral are an important asset for financial institutions, and large-scale defaults on these loans can be detrimental to financial stability (Mian and Sufi, 2009; Jorda, Schularick and Taylor, 2016). The literature on *residential* mortgages posits three causes of defaults: *strategic*, *cash flow*, and *double-trigger* default.[1] Since the property value of non owner-occupied commercial real estate (CRE) is directly linked to cash flows generated by the property, risks to these cash flows would have stronger implications for CRE loan default.[2] While the assessment of risks to mortgage default is relevant for institutional investors who hold commercial mortgage-backed securities (CMBS), it is unclear how investors manage these risks to their asset portfolio. This is of particular relevance in the context of opaque assets such as CMBS, as the lack of proper assessment of mortgage default risk is perceived as one of the main causes of the Great Recession.

In this paper, we study the role of cash flows from renting out CRE for mortgage delinquencies, and explore how insurance companies manage these cash flow risks. We exploit rich data on mortgages included in CMBS deals, which contains detailed mortgage and property characteristics, as well as information about the lease contracts between borrowers and their core tenants. We show that lease expiration dates have a strong positive effect on CRE mortgage delinquencies, in line with the idea that borrowers suffer shocks to their rental cash flow income if tenants decide not to renew their contracts. This effect is relevant mostly for offices, especially since the onset of the COVID-19 pandemic when demand for office real estate dwindled as a result of hybrid work arrangements. We provide evidence that insurance companies monitor the cash flow risks of the underlying CRE collateral of their CMBS, and sell bonds relatively more exposed to cash flow risks after the pandemic. Finally, we show that the composition of insurers' CMBS portfolio has implications for how these investors react to salient risks in the remainder of their asset portfolio.

[1] First, default can occur if borrowers miss mortgage payments due to the lower cash flows they receive. Second, strategic defaults occur when financially healthy borrowers choose to cease payments, for example if the property value falls below the outstanding loan balance. Third, the "double-trigger" theory posits that the simultaneous concurrence of these two conditions is necessary for a default event. See, for example, (Campbell and Cocco, 2015; Foote and Willen, 2018; Schelkle, 2018; Ganong and Noel, 2023).

[2] The degree of sensitivity of mortgage credit risk to property generated cash flows is embeded in regulation, as in CRE20 of BCBS (2022).

We start our analysis with a simple model framework that illustrates the link between borrower cash flows obtained from rental income, property values, and mortgage delinquency, highlights how such information would influence CMBS investors behavior. Since the value of a commercial property equals the present discounted value of the cash flows that can be obtained from renting such property, changes in cash flows and changes in property value are intrinsically connected. Lower demand for CRE would affect delinquencies through their effects on cash flows obtained from renting out properties, and risks to these cash flows are more likely to materialize once a tenant agreement ends. Importantly, if lease agreement information is monitored by investors, then these investors would be more likely to sell CMBS with a larger share of mortgages linked to leases expiring when faced with unexpected shocks to collateral demand. Moreover, this monitoring effort could make investors less reactive to risks in other assets if their capacity to assess risks is limited. This framework provides us with a set of hypotheses connecting information about CRE cash flow risks, loan delinquency, and institutional investors' trading behavior, which we test in our empirical exercises.

To perform our empirical analysis, we use a comprehensive monthly panel data on CMBS deals, bonds and loans against CRE, along with detailed information on the asset portfolio of US insurance companies. The mortgage data enables us to observe the default status of each loan while also capturing relevant information about the underlying properties, including their location and designated use. It also contains rental contract characteristics such as lease expiration dates and tenant occupancy share for certain types of properties. Following our model framework, we posit that changes in rental cash flows are more common when tenant lease contracts expire, since elevated early termination fees can incentivize tenants to retain their lease until it expires.[3] The lease expiration timing generates a negative cash flow shock for borrowers if they need time to find a new tenant or if they cannot renew the lease at a similar rent. Indeed, we find spikes in delinquency that coincide with months in which the lease contracts of borrowers' main tenants expire, especially for offices.

Next, we explore differences in default for properties with and without leases expiring, before and after the COVID-19 pandemic. The idea is that cash flow shocks should be stronger following a systematic drop in demand for commercial real estate. The post COVID-19 pe-

[3]This should hold true under the condition that the costs of terminating the rental contract early are higher than the savings from moving to a smaller office space.

riod is characterized by structural changes in demand for office space due to work-from-home and hybrid working arrangements (Barrero, Bloom and Davis, 2021). Lower demand for office space reduces current and expected rental incomes, which reduce the value of commercial real estate properties. We show evidence consistent with the presence of a structural shift in demand for office space due to work-from-home, leading to more persistent increases in mortgage defaults, especially for mortgages that experience lease expiration. To the extent that these changes in CRE loan default are sensitive to lease expiration induced cash flow shocks, this evidence points out to the importance of the *cash flow* trigger for CRE mortgage default.

The challenge in establishing a causal link between lease expiration dates and delinquency rates is that these dates can coincide with other shocks that cause delinquency. For example, lease expiration can coincide with regional shocks that lower demand for CRE. Similarly, if mortgages with leases expiring have floating interest rates, increases in reference interest rates that coincide with lease expiration can also cause an increase in delinquency rates. We address these challenges by leveraging on the details of our data, which allow us to include a rich set of fixed effects that capture several static and time-varying confounding factors that could affect delinquency rates. Using the beginning of the COVID-19 pandemic as the treatment period of a shock to the demand for office space, we estimate a differences-in-differences specification, and show that lease expiration triggers increases in delinquencies, with a stronger effect after COVID-19. These effects are economically meaningful, with lease expiration leading to about 1.3 percentage-points higher delinquency in the baseline period, and additional 1.3 percentage-points increase in the post-pandemic period. Finally, the lease expiration effect is stronger for properties which are not fully occupied by the largest tenants, suggesting that relatively larger tenants renew their leases more often. These results highlight the importance of tenancy agreement characteristics and borrower cash flows for measuring how lower office demand impact default rates of CRE loans.

The second step in our empirical analysis consists of understanding how large are insurance companies' exposure to offices through their holdings of CMBS, and the extent to which these investors monitor cash flow risk caused by lease expiration. Fist, we document that insurance companies are the largest investor in CMBS, holding more than two thirds of newly issued private-label CMBS between 2017 and 2022. We also find that the amount of insurers'

private-label CMBS portfolio *not* exposed to offices peaks in 2020, and decreases afterwards, which is indicative of lower demand for CMBS exposed to offices. Nonetheless, insurers remain largely exposed to cash flow risks arising from lower office demand. In our sample, the median insurance company has its private-label CMBS with an average exposure of about 26% to offices.

We formally test if insurers monitor cash flow risks in their CMBS portfolio by asking if bonds more sensitive to cash flow shocks are more likely to be sold following the sudden, unexpected increase in risk caused by COVID-19. Our identification strategy relies on the idea that pandemic-driven lower demand for CRE constitutes an unexpected shock to CMBS cash flows, with stronger effects for offices. As with mortgage default, we estimate a difference-in-differences specification to assess if CMBS with exposure to office-linked loans whose main lease expires within a specific horizon are more likely to be sold after the pandemic. The richness of our data allows us to include institution-time fixed effects, on top of loan fixed effects, time-coupon type and time-rating fixed effects. This comprehensive set of fixed effects addresses concerns that our estimates are contaminated by other time-varying insurer shocks or loan characteristics which could affect insurers' CMBS trading behavior in the post-COVID period.

We find that insurance companies infer risks from shocks to expected cash flows, which affects their trading behavior. Insurance companies are more likely to sell CMBS which are exposed to offices, especially offices with lease expiration in the short to medium-term. This effect is stronger for office-exposed CMBS only in the post-COVID period, which suggests insurance companies are able to identify the relevant property type which is affected by lower demand due to hybrid work arrangements. Furthermore, this effect is present for exposures which capture lease expiration in medium-term horizons ranging from four to six years. For instance, bonds exposed to office lease expiration within six years are over two percentage points more likely to be sold by insurance companies in the post-COVID period. We also show that the share of CMBS acquired by insurance companies with underlying office exposure falls after 2020, along with the share of CMBS exposed to cash flow shocks through lease expiration of office properties. This indicates that insurers monitor risks to their CMBS portfolio, and learn about structural changes that make certain assets more prone to cash flow induced losses.

Finally, we also carve out the spillover effects to affected insurers' trading behavior in the remainder of their securities portfolio. Our evidence suggests that insurance companies put in effort to assess underlying risks in their portfolio of securitized assets as they become more relevant, or salient, as was the case since the onset of the COVID-19 pandemic. By locking down valuable monitoring efforts, this gives rise to the possibility that insurance companies are subsequently less sensitive to reacting to increases in capital requirements or other consequences of holding on to riskier assets in the remainder of their portfolio. Indeed, we find that insurance companies are *less* likely to sell riskier bonds in the post-COVID period if they have a larger exposure to offices in their CMBS portfolio, even when controlling for time-varying unobserved heterogeneity at the insurer and security level. This points to the limited resources that financial institutions have at their disposal to effectively constrain their exposure to investment with lurking risk (e.g., Chen et al., 2020).

All in all, our evidence lends support to the idea that institutional investors do monitor, if prompted to do so, the lease expiration for CRE default. In particular, we highlight the usefulness of property and tenancy agreement information for identifying loans materially dependent on borrower cash flows. The results also suggest the full effect of lower office demand on loan default and, consequently, its implications for financial stability, is yet to materialize. Moreover, these cash flow triggers of mortgage default should also take place in other segments of the market, including mortgages held by banks. Finally, our results indicate that the financial sector did improve in assessing risks to complex financial products such as mortgage-backed securities. Nonetheless, despite their apparent ability to monitor CMBS underlying cash flow risks, insurers still carry large exposure to these risks, and their monitoring efforts might compromise their ability to react to risks in other assets.

Related literature. Our paper contributes to a broad literature that studies insurance companies portfolio decisions, and how they react to risks in their asset portfolio.[4] The literature has documented that insurance companies react to changes in observable risk such as downgrading (Ellul, Jotikasthira and Lundblad (2011)), and highlighted how regulation affects the incentives to react to such changes in observable risk (Chen et al., 2020; Becker, Opp and

[4]Examples include Ge and Weisbach (2021), Koijen and Yogo (2022), Ellul et al. (2022), Bhardwaj, Ge and Mukherjee (2022), Koijen and Yogo (2023), Sen (2023), and many others.

Saidi, 2022). We contribute to this literature by showing that insurance companies monitor underlying cash flow risks of their securities ahead of the materialization of these risks, in the context of lower demand for offices after the COVID-19 pandemic. However, we also find that the additional effort undertaken to monitor those cash flow risks limits insurers' ability to react to salient risks in other assets. This finding is particularly relevant given the importance of insurance companies as institutional investors in corporate bond markets (Bretscher et al. (2022)) and CMBS (Becker, Opp and Saidi (2022)), and their role absorbing fluctuations in asset prices (Chodorow-Reich, Ghent and Haddad (2021)).

We also contribute to the literature studying risks in securitized assets and mortgage-backed securities in particular.[5] When looking at differences in asset performance, several papers investigate how retention by MBS issuers can signal asset quality. Begley and Purnanandam (2017) show that RMBS with larger equity share retention by the issuer have lower delinquency rates ex-post. Flynn, Ghent and Tchistyi (2020) show how the structure of risk retention can be used to signal asset quality, instead of the share in the most junior tranches. Ashcraft, Gooriah and Kermani (2019) argue that CDOs allow investors to reduce their exposure to CMBS, and that this reduction explains poor security performance ex-post. In contrast, we identify time-varying loan level information that allows investors to predict cash flow shocks to CMBS collateral, and ask the extent to which these investors use this information to anticipate losses to their CMBS caused by loan default. We find evidence that institutional investors monitor risks to the collateral in the underlying pool of mortgages of the CMBS they hold and rely on such information to trade and reduce their exposure to expected losses driven by cash flow shocks.

Finally, this paper relates to the literature exploring the determinants of mortgage default, and the impacts of work-from-home adjustments in CRE valuation (Ambrose and Sanders, 2003; Buschbom et al., 2021; Goldberg and Jr., 2002).[6] As in our study, Glancy and Wang (2023) highlights the importance of lease expiration, showing that it affects office vacancies and loan performance, and documents heterogeneity of these effect with respect to property

[5] See, for example, DeMarzo and Duffie (1999), DeMarzo (2005), Demiroglu and James (2012), Ghent, Torous and Valkanov (2019) and Aiello (2022).

[6] While several papers study the relevance of strategic and cash flow motives for default of *residential* mortgages (Ganong and Noel, 2023; Bhutta, Dokko and Shan, 2017; Gerardi et al., 2018), less attention has been devoted to the topic among *commercial* mortgages.

types and regional market characteristics such as work-from-home sensitivity. Worse loan performance, however, might not trigger default, as borrowers could still be solvent, despite lower cash flow generated from their properties. Dinc and Yönder (2022), for example, show that borrowers default on their mortgages even though they have enough liquidity, interpreting this as evidence of strategic default. In that sense, our study complements their analysis by explicitly providing the direct causal link between cash flow shocks originated by lease expiration and CRE loan default rates, showing that these effects are stronger as a result of hybrid work arrangements. Finally, while there is a broad literature studying the impacts of work-from-home adjustments to CRE values (e.g., Ghosh et al., 2022; Gupta, Mittal and Nieuwerburgh, 2023), up until now this literature had not documented a direct link between lower office demand and CRE mortgage default (Nieuwerburgh, 2022).

2. Lease Expiration, Cash Flow Shocks, and CRE Mortgage Default

Our conceptual framework takes the perspective of a borrower that acts as a landlord deriving income from renting out a commercial property, e.g. offices or retail space, to a firm. Following Gupta, Mittal and Nieuwerburgh (2023), the present value of their commercial property V_0 can be expressed the expected present discounted value of future Rev_t minus future $Cost_t$. Rev_t corresponds to lease revenue, which depends on revenue from non-expiring leases and revenue from expiring leases. The latter is composed by the share of occupied offices that are renewed after lease expiration, the share of vacant offices that have new leases signed, and the market price of rent. The cost term, $Cost_t$, corresponds to operating expenditures, capital expenditures, and lease commissions. In that case, we can write the value of a property V_0 as:

$$V_0(z) = E_t \left\{ \sum_{j=0}^{\infty} M_{t,t+j} \Big[Rev_{t+j}(z) - Cost_{t+j}(z) \Big] \right\}, \tag{1}$$

where $M_{t,t+j}$ denotes the relevant stochastic discount factor at time t relative to time $t+j$. The literature studying residential real estate distinguishes between strategic or equity based default, and cash flow based default. The former occurs when the value of a property falls below the total cost of mortgage payments. The latter occurs when borrower income (or cash

flows) fall below the amount required to pay contemporaneous mortgage payments. Let i_t denote the total period cost of mortgage debt servicing of a property, and $I_t := \sum_{t=0}^{\infty} M_{t,t+j} i_t$ denote the present value of total mortgage payments. Then default occurs if

$$\min\{V_0(z) - I_t,\ Rev_t(z) - Cost_t(z) - i_t\} < 0. \tag{2}$$

The first term in brackets captures *strategic default*, whereas the second term in brackets captures *cash flow based* default. To understand the link between lease expiration and default, recall that revenue Rev_t is affected by the share of expiring leases (which could be renewed or not), with potentially lower net cash flows in case of lower than expected renewal rates. Importantly, since changes in net cash flows also affect the value of CRE properties, both terms in Equation 2 could be triggered by a lease expiration in which the tenant opts for a smaller occupancy, or in which the property goes vacant and landlord has to find a new tenant. Absent large demand shocks for office space, we would expect downsizing to be smaller and the duration of lease search to be temporary.

Hypothesis 1: *Lease expiration temporarily increases delinquencies in benign periods.*

Sudden shocks to demand for offices should reduce the share of office space which is occupied after a lease expiration (either by downsizing or lack of renewal) and increase the search time for a new tenant for vacant units. Moreover, we expect that a borrower's revenue obtained from a new lease would be systematically lower after the demand shock, further reducing Rev_t. Thus, longer search time and lower rental revenue should lead to a more prolonged period of delinquencies. Consequently, hybrid work arrangements which decrease office demand should lead to a more prolonged period of delinquencies.

Hypothesis 2: *Lease expiration persistently increases mortgage default after a demand shock.*

Since CMBS are held mostly by insurers in the US, changes in the riskiness of these assets might lead to changes in behavior of these investors. First, to the extent lease expiration is observable by insurance companies, the increase in future delinquency probability caused by lease expiration should reduce the relative attractiveness of holding CMBS with a larger share of mortgages whose tenancy agreements are about to expire. Since lower demand increase the persistence of default triggered by lease expiration, investors are more likely to monitor characteristics associated with cash flow risks if prompted to do so following unexpected

shocks to CRE demand. Consequently, if insurers monitor risks to the cash flows of their securitized investments, they are more likely to sell CMBS with a larger exposure to cash flow shocks after the pandemic.

Hypothesis 3: *Conditional on monitoring, investors should sell CMBS with relatively more mortgages undergoing lease expiration after the COVID-19 pandemic.*

Finally, this added monitoring effort triggered by an unexpected increase in cash flow risks to CMBS portfolio can affect insurers' trading activity in *other* assets. To understand why, notice that if insurance companies' risk assessment capacity is limited, insurers which exert more effort monitoring risks to their CMBS after the onset of the COVID-19 pandemic could become less sensitive to consequences of holding riskier assets. This reduction in the salience of risk characteristics for other bonds in insurers' portfolio would lead to lower sales in response to changes in observable risk, such as ratings downgrade or capital surcharges.

Hypothesis 4: *If risk assessment capacity is limited, insurers who exert more effort assessing CMBS cash flow risks should be less reactive to risks in other assets.*

The framework above illustrates how cash flow shocks are intrinsically linked to property values, and such shocks can trigger default in the event the NPV of each property becomes negative. Importantly, commercial real estate properties could have different uses and cash flow characteristics according to the types of firms that occupy these spaces. This could affect the cash flows obtained by landlords both during normal times and in the presence of demand shocks as in the Global Financial Crisis (GFC) and in the recent post COVID-19 period, as demand for office space has dwindled (Gupta, Mittal and Nieuwerburgh (2023)).

3. Data Description

Our data comes from two main sources: Trepp and the National Association of Insurance Companies (NAIC). Trepp is a lead provider of commercial real estate collateralized products data, which is established in the existing literature (Flynn, Ghent and Tchistyi (2020)). It collects origination information from CRE mortgages, CMBS deals and bonds, which is obtained from various sources. It includes detailed information such as property type and location, mortgage maturity, amount, interest rates and delinquency information for each distribution date. We classify loans according to the use of the property which serves as col-

lateral for the loan. We distinguish between *Office*, *Retail* and further property types.[7] The data also contains information on lease agreements between borrowers and tenants. For the purpose of our analyses, we focus on the lease information for the largest tenant only. Appendix A Table A.1 show that the availability of lease expiration data varies by property type, with Office and Retail as the only two property types for which the date of lease expiration of the main tenant is available for more than 50% of the observations. For that reason we mainly focus on these two property types throughout the paper.

We obtain holdings and trades of fixed-incomes assets of all insurance companies in the U.S. from NAIC. The holdings data is based on NAIC Schedule D Part 1, and contains CUSIP-level end-of-year holdings of fixed-income securities, including CMBS. The trading information is obtained from NAIC Schedule D, Parts 3 and 4, which contain information on acquisitions and dispositions of fixed income assets by insurance companies, respectively. We identify actual trades (sales and purchases) using a procedure similar as Becker, Opp and Saidi (2022), which is described in Appendix C.

We restrict our analyses to the post-2017 period[8]. This ensures that we mitigate concerns about the influence of the Global Financial Crisis (GFC), for example elevated delinquency rates responding to demand shocks that originated during the GFC. Table 1 shows the summary statistics of the mortgages in our sample. Panel A focuses on all properties, which have a median lease expiration year is 2024, and the median mortgage maturity of 10 years. We classify a loan as delinquent if payments are past due for at least 90 days. On average, less than 1% of all loans are delinquent in our sample period (see Table 1), around 10% of our loans have floating interest rates, and less than 1% are recourse loans.

Finally, since our analysis mostly focuses on offices and retail CRE, we provide a breakdown of the characteristics of the mortgages used to finance these property types in Panels B and C of Table 1, respectively. Relative to retail, offices have floating interest rates more frequently, lower delinquency rates and similar maturity. Moreover, the mean and the median share of each property occupied by the largest tenant is smaller in offices than in retail.

[7] These are classified as *Multifamily*, *Mixed Use*, *Healthcare-Nursing*, *Lodging-Restaurants*, *Industrial and Warehouses*, and *Other*. The details of how these types are obtained, along with other details of our data cleaning procedure, can be found in Appendix B.

[8] Our Trepp sample covers CMBS information until June 2022.

4. Cash Flow Shocks and Mortgage Delinquencies

4.1. The Role of Lease Expiration

First, focusing on mortgages whose lease expiration dates occur between 2017 and 2021, we evaluate the importance of lease expiration induced cash flow shocks to borrowers in driving delinquency rates. Using this sample period, we examine delinquencies rates in the time window of one year prior and one year after the expiration date of the main lease. Given our definition of a loan being delinquent if it is at least 90 days, or about 3 months, past due, we expect to see delinquency rates to increase comparatively more only *after the third month* in which a lease expires.

Figure 1 shows the average delinquency rates for all property types for which such information is available. As expected, we observe that delinquency rates increase with the sharpest increase occurring exactly in the fourth month after lease expiration date. This is in line with the idea that cash flows shocks from a lease ending induces borrowers to stop making payments on their mortgages. This may be because existing the borrower cannot find a new tenant immediately or the lease generates lower income than the previous one. Moreover, delinquency rates seem to converge back to their pre-lease expiration trend approximately 10 months after the lease expiration, which indicates borrowers resume their payments once a new tenancy agreement is secured. This further illustrates the importance of cash flow shocks to the default behavior of CRE borrowers.

This preliminary analysis, however, does not account for potential differences in delinquency rates depending on the use of the property. There are reasons to assume that such differences exist. First, the existing use of the property might limit a borrower's ability to find a new tenant. For example, it may be more difficult to re-purpose office space for other uses which can increase search costs and lower expected revenue after an existing lease expires. Second, firms in different sectors might be more likely to renew their lease contracts, and to the extent these firms select into different types of properties, that would differentially affect borrowers depending on the property they are financing with their loan. Third, it may be borrower-specific characteristics that matter. For example, some borrowers who take out mortgages against certain types of properties might struggle more to find a new ten-

ants, which would be the case if search frictions are different when looking for office or retail tenants. With that in mind, we split our sample into two sub-samples, offices and other retail properties. Figure 2 shows a remarkable difference in delinquency behavior for different property types. The plot on the left-hand side shows sharp increases in delinquency rates of offices following the end of the main lease agreement. By contrast, the plot on the right-hand side suggests that increases in delinquency rates of retail properties are more short lived, with shocks introduced by end of lease agreements more transitional in nature. Overall, these preliminary results indicate that cash flow shocks are stronger predictors of office delinquencies, but less so for retail properties.

So far we have examined delinquencies focusing on the exact timing of the lease expiration for a specific property, but not explicitly considering the delinquency behavior of mortgages without leases expiring. This difference in exposure to cash flow shocks caused by lease expiration can be particularly relevant in the post-COVID period, as lower demand for offices could interact with these contractual terms and lead to more persistent losses to landlords. To the extent that lower CRE demand magnifies cash flow shocks, one would expect mortgages with leases expiring in the post-COVID period to perform worse than mortgages which are not subject to such cash flow shocks. We assess differences in delinquency of properties with and without leases expiring by looking at office/retail properties for which we do have lease expiration information (i.e., we know if the main lease expires or not), and zoom in the immediate period before/after the start of the COVID pandemic. We compare the average delinquency rate of loans with leases expiring in 2021-2022 with the average delinquency rates of loans without leases expiring in these two years.

The results are shown in Figure 3. The left-hand side plot shows a remarkable pattern for office mortgages with and without leases expiring in 2021-2022. Delinquency rates for the former group are pretty much stable through the entire period, whereas there is a large spike in delinquency rates for mortgages whose main leases expired in 2021-2022. This further indicates that cash flow shocks are a relevant determinant of office mortgage default, and indicates that aggregate delinquency rates do not capture the extent to which work-from-home arrangements trigger CRE mortgage default given its effects on office demand. By contrast, the trajectory of retail mortgage delinquency in the right-hand side plot in Figure 3 shows a different pattern. Delinquency rates spike immediately at the onset of the COVID-19 pan-

demic, which coincides with lock-down period during which retail stores did not generate income to tenants. Following that initial shock, mortgages with leases expiring in 2021-2022 demonstrate persistently higher delinquency rates which suggests that lease expiration matters for the adjustment to the initial shock. In other words, while cash flow shocks do not seem to *cause* mortgages to go from performing to non-performing in the case of retail, they do seem to affect the *persistence* of the initial increase in delinquency rates.

In what follows we focus on offices rather than retail properties. It allows us to focus on structural changes in the demand for office space without explicitly considering the implications from the initial lock-downs on businesses. Furthermore, if institutional investors trade before losses materialize, then one would expect their trading behavior to be based on office exposure, if these mortgages losses can be predicted by shocks to expected cash flow.

4.2. The Causal Effect of Lease Expiration on Mortgage Delinquency

The preliminary analysis so far suggests a key role for lease expiration dates in driving delinquency behavior for CRE mortgage borrowers, especially for office properties. Nevertheless, there are a range of other factors that could be driving the delinquency dynamics we observe for properties subject to lease expiration. For example, lease expiration dates could correlate with systematic or region specific shocks that affect the US economy in specific times, such as the Global Financial Crisis and the recent onset of the COVID-19 pandemic. Moreover, loans for which we have lease expiration could also have specific characteristics, such as floating interest rates, which can make them more susceptible to increases in delinquency in times of increases in interest rates.

To evaluate the causal relationship between lease expiration and mortgage default, we leverage the richness of our data, which allow us to compare other identical mortgages which have leases expiring and not. First, we estimate the following specification:

$$I_{jtr}^{D90} = \alpha_j + \alpha_{tr} + \alpha_{tj(floating)} + \sum_{\iota \in [-15,15] \setminus \{0\}} D_{jt}^{\iota} \delta_{\iota} + \varepsilon_{jrt}, \tag{3}$$

where I_{jtr}^{D90} is an indicator variable equal to 1 if loan j, for a property located in city r, is delinquent for more than 90 days in month t, D_{jt}^{ι} equals 1 if loan j is ι periods after lease ex-

piration in month t. α_j and α_{tr} are loan and city-year fixed effects, which allow us to control for unobservable loan level and time-varying regional characteristics that might influence default rates. We also add year-interest rate type fixed effects to capture differences in delinquency between floating and fixed interest rate loans, which could arise due to large interest rates in the post pandemic period. The coefficients of interest δ_ι capture the percent difference in delinquency rates ι periods before and after lease expiration, relative to the moment in which the lease expires. Importantly, the use of comprehensive fixed effects ensures this variation does not correspond to time-varying regional shocks or to index rate characteristics of the mortgages that could also influence delinquency behavior. We only include loans for which we have lease expiration information in our regressions.[9] We cluster our standard errors at the loan level.

Since lower office demand caused by work-from-home (WFH) arrangements might affect CRE mortgage default rates, we estimate equation 3 separately for the period before and after the COVID-19 pandemic started (where we consider the beginning of the pandemic as March 2020). Intuitively, if borrowers face lower demand for their properties as a result of structural changes associated with work-from-home preferences, then one would expect the cash flow shocks introduced by lease expiration to be long lasting. Conversely, absent demand shocks, the initial drop in cash flows would cease after the borrower is able to find a new tenant, and delinquency rates would slowly transition back to its pre-lease expiration levels.

The results are shown in Figure 4, where the two plots in Figure 4 indicate that WFH demand adjustment did affect the persistence of the effect of cash flow shocks to delinquency rates. While the initial effect is similar in both periods, delinquency rates in the pre COVID-19 panel on the left show that delinquency rates begin to converge back to their initial level after one year of the lease expiration. Our point estimates indicate that, relative to the lease expiration month, a mortgage experiences a 1p.p. higher delinquency fifteen months after the lease expiration. In contrast, the effects of the cash flow shock induced by lease expiration are more long lasting in the post COVID-19 period, with delinquency rates gradually becoming larger following a lease expiration. The difference in relative delinquency between

[9] We do this to avoid including loans with leases expiring in our control group (which could happen for loans for which we do not observe that information, but might experience a lease expiration nonetheless).

the lease expiration month and fifteen months after is about 3 p.p., almost three times as the same point estimate from the pre-COVID period.

To quantify the differences in post-lease expiration delinquency behavior before and after the onset of the COVID-19 pandemic indicated in Figure 4, we estimate a comprehensive triple differences specification:

$$
\begin{aligned}
I_{jtr}^{D90} = {} & \alpha_j + \alpha_{tr} + \alpha_{tj(floating)} + \gamma_1 Post\ Expiration_{jt} \\
& + \beta_1 Post\ Expiration_{jt} \times\ Post\ Covid_t + \beta_2 Post\ Expiration_{jt} \times\ Ind\ Office_j \\
& + \beta_3 Post\ Covid_{jt} \times\ Ind\ Office_j \\
& + \beta_4 Post\ Expiration_{jt} \times\ Post\ Covid_t \times\ Ind\ Office_j + \varepsilon_{jrt}, \qquad (4)
\end{aligned}
$$

where $Post\ Covid_t$ is a dummy equal to 1 after March 2020, $Post\ Expiration_{jt}$ equals 1 if loan j had its main lease expiration before or in month t, and $Ind\ Office_{jt}$ equals one if loan j is linked to an office. The coefficient of interest, β_4, captures the difference in the effect of lease expiration induced cash flow shock on delinquency rates since the onset of the pandemic. The use of a broad range of fixed effects addresses concerns that our results could capture other loan characteristics and time-varying regional shocks that could drive delinquency rates. We cluster standard errors at the loan level to account for correlation across loans.

The results are shown in Table 2. Across all specifications the results for the triple interaction term is positive and statistically significant, and the economic magnitude is relevant. The baseline effect of lease expiration on mortgage delinquency increases by about 1.2 p.p., meaning the effect of cash flow shocks on deliquency rates is twice as strong after COVID-19 pandemic. Cash flow shocks increase delinquency rates by more than 2 percentage-points when compared to the average delinquency rate 0.6% for properties without expired leases in the post-pandemic. This is an economically significant effect, with delinquency rates for offices mortgages whose main tenancy agreement expired more than four times as large as delinquency rates of mortgages that do not experience such cash flow shocks. These results reinforce the notion that demand shocks caused by hybrid work arrangements, which became prevalent after the beginning of the COVID-19 pandemic, further exacerbate the effects of

cash flow shocks on CRE mortgage delinquency rates.

CMBS exposure to regional work-from-home characteristics. Our analysis so far hinges on the observation that, by being relatively more affected by hybrid work arrangements, demand for office properties are also relatively more affected by the work-from-home shock, hence leading to more persistent cash flow shocks to rent revenue. Importantly, another dimension of heterogeneity in exposure to work-from-home adjustments refers to regional characteristics. For instance, cities like San Francisco or even New York are perceived to be more affected by hybrid work arrangements than cities like Charlotte (Gupta, Mittal and Nieuwerburgh, 2023).

While we cannot measure demand for office space, we can nevertheless assess how mortgages in our sample correlate with measures that have been constructed to capture regional sensitivity to work-from-home. We do so using the measure of jobs that can be performed remotely by Dingel and Neiman (2020), which should broadly indicate which areas are more likely to be affected by work-from-home arrangements. Figure A.3 shows the distribution of the percentage of teleworkable jobs in an MSA, for the office-linked mortgages in our sample and for all MSAs. Relative to the distribution across all MSAs, office-linked mortgages in our sample are located in areas with higher sensitivity to work-from-home shocks.

4.3. Cash Flow Shocks and Relative Tenant Occupancy

Our results so far focus on the sensitivity of default rates along the extensive margin of lease expiration—namely, whether a lease expiring is associated with increases in default—but is silent about the intensive margin—i.e., whether the relative size of a occupant also affects default. On the one hand, tenants which occupy a larger share of a property might also have more bargaining power and obtain better renewal offers, hence more likely to renew their contracts. On the other hand, since these tenants also represent a larger share of the rental income obtained from a property, unexpected vacancy would have a larger impact on borrower cash flows.

We investigate these opposing forces by analyzing how our lease expiration results interact with tenant occupancy %. Figure A.2 shows that Offices and Retail CRE have similarly

shaped distributions of the percentage occupied by a property's largest tenant. In both cases there is substantial mass at 100%, with around 16% of the tenants occupying the whole rental unit. For that reason, we re-estimate Equation 4 splitting our sample between mortgages whose underlying properties are fully occupied by the largest tenant and those with partial (below 100%) occupancy. Additionally, we estimate a version of Equation 4 using the entire sample and adding one additional fourth interaction term $Ind\ Full_{jt}$, which equals 1 if a property is fully occupied by its largest tenant in month t. As before, we cluster standard errors at the loan level.

Table 3 shows the results, with the columns 1 to 3 focusing on properties fully occupied by the largest tenant, columns 4 to 6 partially occupied by the largest tenant, and columns 7 to 9 with the fourth differences specification using the whole sample. Consistent with the idea that relatively larger tenants have more bargaining power and obtain more favorable conditions for renewing, we observe that both the baseline effect of lease expiration *and* the post-pandemic differential effect of cash flow shocks to Office CRE mortgage default are stronger for properties partially occupied by the largest tenant. This further indicates that characteristics of the underlying tenancy agreements of properties financed by securitized mortgages are important for CMBS cash flows.

5. Do Insurers Monitor Cash flow Risks?

The strong link between expected changes in the tenancy agreement of a specific office, and default rates of the mortgage linked to that property suggest, have implications for assets whose cash flows depend on the performance of these CRE mortgages. In particular, insurance companies' cash flows obtained from their holdings of CMBS might be compromised if the underlying mortgages become non-performing. This raises several fundamental questions: How large and what is the dynamics of the exposure of insurance companies to office CRE through their holdings of CMBS? Moreover, given the predictable nature of expected cash flow shocks to mortgage payments, do insurance companies monitor such risks and sell bonds based on such cash flow shocks to mortgage CRE? Finally, does lower office demand introduced by work from home preferences in the post-pandemic period affect the trading behavior of these intermediaries? We explore the answers to these questions next.

5.1. Insurer Holdings of WFH-sensitive CMBS

We start by leveraging our data and documenting the importance of insurance companies for the private-label CMBS market, and details of their exposure to shocks linked to office collateral. We are in a unique position to do so, given our access to details CMBS information (including origination dates) and detailed information on the portfolio of insurance companies.

First, we collect information on end of year outstanding balances and amount issued for all private-label CMBS in our sample, and identify which bonds are held by insurance companies at the end of each year. Figure 5 shows that insurance companies are the main investors in CMBS markets. By the end of 2022, insurance companies hold about $ 600 billion out of $800 billion outstanding. Similarly, between 2017 and 2019, insurance companies acquired more than 70% of the total amount of new issues of private-label CMBS. Interestingly, the share of new CMBS originated held by NAIC insurers in the same year drops to about 65% between 2020 and 2022. This reduction in the overall amount of CMBS held by insurance companies is indicative of lower insurer demand, which could arise as lower office demand lead to mortgage default rates.

We further explore how the dynamics of holdings of CMBS by insurance companies varies over time, by documenting the exposure of insurance companies CMBS portfolio to office CRE collateral. We classify a bond as *exposed* if it has *any* mortgages financing office properties within its pool of collateral. We then calculate the share of CMBS that is exposed to offices out of the entire portfolio of private-label CMBS held by insurance companies. Figure 6 shows the share invested in non-exposed bonds for each year. One can see that the share of CMBS that exposed to offices increases yearly until 2020, at which point such trend is reversed. In particular, insurance companies increase the share of CMBS not exposed to offices in 2021 and 2022 by about 5%. This further suggests insurers reacted to risks arising from lower demand for office space by adjusting their holdings of CMBS.

Next, we document the exposure of insurance companies to risks related to expiring tenancy agreements of mortgage financed office properties. We calculate the percent share of office mortgage in each deal associated with a CMBS bond in our sample, for all offices, as of June 2022. We also compute the share of this portfolio of office-linked CMBS which has

underlying leases expiring between 2023 and 2026. Intuitively, this percentage represents how exposed to office mortgages a particular bond is, abstracting from seniority considerations. Figure 7 shows the resulting distributions. The left plot considers exposure to any office properties, while the right plot considers exposure to office properties with at least one underlying mortgage with a tenancy agreement expiring between 2023-2026. The median insurance company has its private-label CMBS with an average exposure of about 26% to office properties, and 4.6% to office properties with tenancy agreements expiring in 2023-2026. Importantly, there is considerable heterogeneity in the size of the average exposure of CMBS bonds to office properties among insurance companies, with the top decile of the distribution of insurers with an average exposure of 39% of their portfolio to offices, and 10% to offices with underlying lease expiration.

5.2. CMBS Exposure to Cash Flow Shocks and Trading Behavior

Given the degree of exposure heterogeneity across insurers, we next ask whether more exposure leads to differential trading behavior. Insurance companies might anticipate the effect of work-from-home (WFH) shocks on the cash flows and on the value of their CMBS, and attempt to sell these bonds. Moreover, even if insurance companies do not trade CMBS based on office exposure alone, they could still anticipate shocks to their assets caused by upcoming lease expiration.

First of all, it is instructive to understand if there is evidence that investors observe *and* trade based on the underlying characteristics of mortgages included in CMBS. In particular, to the extent lease expirations *predict* delinquency rates, insurance companies might attempt to offload exposed CMBS in anticipation of losses associated with default. Moreover, to the extent this information might be less salient to other market participants, this could put insurance companies in a unique position of trading at more advantageous conditions than when default risk materializes. To test this, we estimate the following specification:

$$I_{ijt}^{sold} = \alpha_{it} + \alpha_{ij} + \alpha_{tj(coupon)} + \alpha_{tj(NAIC)} + \beta_1 I_{jt}^{Y} + \beta_2 I_{jt}^{Y\ Office} + \varepsilon_{jt}, \tag{5}$$

where I_{ijt}^{sold} is a dummy variable which equals 1 if insurer i actively sold any fraction of

security j in year t.[10] I_{jt}^{Y} and $I_{jt}^{Y\ Office}$ are indicator variables capturing two measures of exposure, lease expiration within one year, and delinquency rates, for all properties and offices, respectively. α_{it} and α_{ij} are insurer-time and insurer-security fixed effects. We also include time-interest type fixed effects $\alpha_{tj(coupon)}$ and time-NAIC designation fixed effects $\alpha_{tj(NAIC)}$, to capture time-varying willingness to trade bonds with fixed interest rates or different credit ratings. We use exposure to lease expiration in the following year and exposure to underlying delinquency in the current year. Intuitively, these results should indicate whether insurers are more likely to sell bonds which are *currently* underperforming, or are *expected* to underperform, in the following year. Standard errors are clustered at the security level.

The results are shown in Table 4. One can see that only *realized*, but not *expected*, underlying losses trigger CMBS sales by insurance companies. Importantly, while most of the variation in realized losses (columns 3 and 4) comes from office properties, the variation in expected losses does not depend on property types. This is consistent with the notion that insurance companies' selling decisions generally depend on losses to the underlying collateral having actually materialized. This suggests that they do not, on average, monitor bond performance as related to pending risks. The work-from-home shock leads to a revaluation of office properties, however. Therefore, if insurance companies have the capacity to monitor such risks once they become more salient, we would expect them to react to *expected* losses only after the onset of the COVID-19 pandemic.

To explore this possibility, the second step in our analysis is to understand to what extent insurance companies anticipate demand adjustments due to work-from-home shocks, which became prevalent with the pandemic. The WFH transition reduces uncertainty regarding which types of real estate will be affected by realized and expected shocks. This provides insurance companies with a unique opportunity to anticipate which CRE assets will be most affected by demand-induced cash flow shocks, and to potentially trade before losses materialize. To understand if insurance companies trade based on expected cash flow shocks, we test if they sell private-label CMBS with larger exposure to office mortgages with leases expiring in different time horizons more frequently after the pandemic started. Formally, we estimate the following specification:

[10] For details on how this variable is constructed, see Appendix C.

$$I_{ijt}^{sold} = \alpha_{it} + \alpha_{ij} + \alpha_{tj(coupon)} + \alpha_{tj(NAIC)} + \beta_1 Post\ Covid_t \times I_{jt}^{Exp(\tau)} + \beta_2 Post\ Covid_t \times I_{jt}^{ExpOffice(\tau)} + \beta_3 Post\ Covid_t \times I_{jt}^{Office} + \varepsilon_{ijt}, \quad (6)$$

where $Post\ Covid_t$ equals 1 after 2019, $I_{jt}^{Exp(\tau)}$ and $I_{jt}^{ExpOffice(\tau)}$ are dummies which equal 1 if bond j is exposed to mortgages whose main lease contracts expires within $t + \tau$ years, for all properties and offices only, respectively. α_{it}, α_{ij}, $\alpha_{tj(coupon)}$, and $\alpha_{tj(NAIC)}$ are, respectively, insurer-time, insurer-security, time-coupon type, and time-NAIC designation fixed effects. $I_{jt}^{Office(\tau)}$ is a dummy which equals 1 for CMBS with exposure to any office CRE in the underlying pool of mortgages, and should capture overall willingness to trade office exposed CMBS in the post-COVID period. We estimate this specification for six yearly horizons to gauge how much in advance insurance companies react to cash flow risk on their underlying collateral. Standard errors are clustered at the security level.

It is worth considering the implications of having an unconditional office-exposure dummy $I_{jt}^{Office(\tau)}$ alongside a horizon-sensitive lease-expiration dummy $I_{jt}^{ExpOffice(\tau)}$, for lease expiration within τ years. A positive β_3 would indicate that shocks expected to materialize *beyond* τ years are still relevant for insurers, as shocks happening *within* τ years would be captured by β_2. Thus, if insurance companies only care about the type of collateral, but *not* about the expected timing of the cash flow risks, we would expect β_3 to be positive for all specifications. If short-term expected losses carry greater weight (e.g., if insurers consider the present discounted value of these losses), then for sufficiently large values of τ we would expect β_3 to decrease and β_2 to be positive and significant.

The results are in Table 5, with the column numbering corresponding to τ. The differences in the propensity of insurance companies to sell bonds more exposed to offices that expire in the near future increase monotonically with the length of the expiration horizon. In particular, insurance companies are about one to three percentage points more likely to sell bonds which have office mortgages that expire in the next four to six years after the COVID-19 pandemic than before (columns 4 to 6). For reference, the mean of the dependent variable I_{ijt}^{sold} equals 0.087 for private-label CMBS, indicating a meaningful economic effect arising from exposure to cash flow shocks expected to materialize in the medium term.

Importantly, these effects are significantly different from those on insurance companies' trades in all other office properties (captured by β_3) and in all other non-office properties with imminent lease expirations (captured by β_1). The coefficient on the interaction with the unconditional office-exposure dummy, β_3, is positive and statistically significant only in columns 1 and 2, in part reflecting lease expirations after one or two years. Taken together, these estimates suggest that insurance companies do react to shocks to office collateral in their CMBS, but only if these shocks materialize within 4 to 6 years.

Furthermore, lease expirations and office properties play no role for insurance companies' selling decisions before the onset of the COVID-19 pandemic. This lends support to the idea that insurance companies are learning about the increase in riskiness of the underlying collateral of CMBS posed by work-from-home demand shocks.

To further bolster our identification assumption that insurance companies react to shocks affecting the cash flow risks of CMBS exposed to offices with leases expiring within a few years from the COVID-19 shock, we also estimate a dynamic difference-in-differences regression of the form:

$$I_{jtr}^{D90} = \alpha_{it} + \alpha_{ij} + \alpha_{tj(coupon)} + \alpha_{tj(NAIC)} + I_{jt}^{ExpOffice(\tau)} + \sum_{\iota \neq 2019} D_{jt}^{ExpOffice(\tau),\iota} \delta_\iota + Controls_{jt} + \varepsilon_{jrt}, \quad (7)$$

where $Controls_{jt}$ include other interaction terms with yearly dummies, as in specification (6). Standard errors are clustered at the security level.

One can see in Figure A.4 that most of the effect we are capturing takes place in 2020, which sees a spike in sale of CMBS more exposure to cash flow risks posed by lease expiration. Reassuringly, we find no visual evidence for violation of parallel trends, supporting our identification assumption that office lease expiration becomes a salient feature of CMBS only after the COVID shock.

5.3. CMBS Acquisitions by Insurance Companies

Having documented that exposure to underlying cash flow shocks affects insurance companies trading behavior, and given the dynamics of CMBS portfolio exposure to offices shown in

Figure 5 and Figure6, a natural follow-up question concerns insurers' purchasing behavior: are insurance companies less willing to acquire private-label CMBS exposed to office CRE? While our analysis is limited since we only observe CMBS held by insurance companies, we can nevertheless study the exposure to office real estate of CMBS acquired in a certain year. Figure 8 show the distribution of office exposure for all CMBS acquired by insurance companies before and after COVID-19. Importantly, there is a large jump in the share of CMBS acquired in 2020-2022 which have no underlying office-linked collateral, with close to 30% of the bonds acquired in 2022 having no exposure to office CRE. The share of acquired CMBS collateralized by office mortgages falls from 30% in 2017-2019 to around 27.9% in 2022.

We observe a similar behavior when looking at exposure to cash flow shocks represented by lease expiration taking place at different time windows. Figure 9 plots the distribution of exposure to offices with leases expiring within a time window, before and after the COVID-19 pandemic. In all cases, there is a shift towards the left of the distribution, with a larger share of the bonds acquired in the post-COVID period having no exposure to immediate cash flow shocks to office CRE. This variation is larger for medium-term lease expiration time windows, with an increase of about 20% in the share of CMBS acquired in the post period that have no mortgages linked to office CRE whose main lease expires within six years, for example. These changes further suggest that insurers do monitor work-from-home triggered changes in demand for offices and the effects of these changes in the valuation of their asset holdings.

5.4. Insurer-level Exposure to CMBS Shocks

Variation in CMBS risk introduced by higher delinquency risk in the post-pandemic period can also affect insurer behavior beyond investors' willingness to trade affected bonds themselves. In particular, Ellul et al. (2022) argues that in response to a drop in insurers' asset values, these investors would de-risk by selling illiquid bonds. Similarly, Becker, Opp and Saidi (2022) show that insurers are more likely to sell downgraded assets which would trigger higher capital requirements relative to assets that would not incur such surcharges.

In our context, a sudden increase in mortgage delinquencies at the onset of the pandemic would trigger an immediate drop in CMBS values for bonds more exposed to retail and lodging properties, as illustrated by Figure 3. Moreover, higher delinquency can also lead to

ratings downgrades and potential added capital surchargers for insurers holding those securitized bonds. In either case, we predict that insurers with larger exposure to such property types would be more likely to sell risky, illiquid bonds.

Importantly, it is unclear how insurers' exposure to offices would affect their trading behavior after COVID-19. On the one hand the dynamic nature of the materialization of cash flow risks arising from WFH suggests larger exposure to offices should not lead to immediate short term adjustments. On the other hand, if investors' ability to assess risks is bounded, then a large office exposure can lead to inattention to risks in other assets, as these insurers would have to use more of their monitoring capacity to track the materialization of cash flow risks represented by office lease expiration.

To understand how exposure to different types of CMBS collateral affects insurers' trading behavior, we estimate the following specification:

$$\begin{aligned} I_{ijt}^{sold} = \alpha_{it} + \alpha_{ij} + \alpha_{tj} + \gamma_1 T_{it-1}^{Office} \times I_{jt}^{T} + \beta_1 Post\ Covid_t \times T_{it-1}^{Office} \times I_{jt}^{T} + \\ \gamma_2 T_{it-1}^{Retail} \times I_{jt}^{T} + \beta_2 Post\ Covid_t \times T_{it-1}^{Retail} \times I_{jt}^{T} + \\ \gamma_3 T_{it-1}^{Lodging} \times I_{jt}^{T} + \beta_3 Post\ Covid_t \times T_{it-1}^{Lodging} \times I_{jt}^{T} + \varepsilon_{ijt}, \end{aligned} \tag{8}$$

where T_{it-1}^{prop} is the lagged exposure of insurer i to properties of type $prop$ in year $t-1$, and I_{jt}^{T} is a a time-varying dummy which equals 1 for riskier bonds. For this specification we cluster standard errors at the insurer level.

In particular, we estimate specification 8 using two different variables: I_{jt}^{Risky}, which is a dummy which equals 1 for bonds with NAIC designation 2 or greater (worse) in year t, and $I_{jt-1}^{Downgrade}$, which equals 1 if bond j has been downgraded in year $t-1$.[11] Our exposure variables are the weighted average percent exposure of insurers' private-label CMBS portfolios to each property type, times the share of private-label CMBS in their entire bond portfolio. Each β_i terms captures the effect of larger exposure to a type of collateral on insurance companies' sales of risky assets. Importantly, we use lagged exposures to deal with the fact that trading within one year would affect exposure in the same year (as it changes insurers'

[11] We use NAIC designation to infer downgrading. Effectively, $I_{jt-1}^{Downgrade}$ equals 1 if bond j had a NAIC designation in year $t-1$ greater than its NAIC designation in year $t-2$.

portfolio composition).

The results are in Table 6. After controlling for time-varying unobserved heterogeneity at the insurer and security level, we yield a negative, albeit statistically insignificant, coefficient on β_1 in columns 1 and 4. This reflects the idea that CMBS exposure to office buildings desensitizes insurance companies to risky securities with higher capital requirements, which they would otherwise sell upon being downgraded (Ellul, Jotikasthira and Lundblad, 2011).

As post-COVID office exposure is associated with greater delinquencies, our previous evidence suggests that insurance companies may be preoccupied with acquiring information regarding office collateral and selling the respective CMBS first. However, in line with higher retail and lodging mortgage delinquencies in Figure A.1, β_1 may be confounded with insurance companies' portfolio rebalancing in the face of retail and lodging mortgage delinquencies, i.e., T_{it-1}^{Office} could be correlated with insurers' respective exposures in their CMBS portfolio. To account for this possibility, we control for such confounding portfolio exposures by estimating (8) in columns 2 and 5 of Table 6.

After doing so, the estimated coefficient on β_1 becomes more negative and statistically significant. Importantly, it carries the opposite sign of the other triple interactions, thereby ruling out that our estimated effect is governed by other, correlated portfolio exposures. Instead, larger exposure to retail leads to more sales of risky assets, which is in line with the idea that facing a devaluation in their asset portfolio, insurers sell illiquid bonds first. Finally, in columns 3 and 6, we additionally control for the triple interaction with insurers' share of corporate bonds more generally, which leaves our coefficient of interest virtually unaltered: larger exposure to offices in insurers' CMBS portfolio is associated with a lower likelihood of selling riskier bonds in the post-COVID period.

6. Financial Stability and Policy Implications

The results in this paper shed light on the ability of institutional investors' to assess underlying risks to mortgage backed securities. Given the importance insurers and CRE mortgages for financial markets, these findings have important policy implications, which we outline below.

6.1. Institutional Investors and Risk in Securitized Assets

The prominent role played by asset-backed securities during the Global Financial Crisis (GFC) prompted regulators to revisit securitization policies, aiming for more aligned incentives for originators, and improved risk assessment by investors. One example are due diligence requirements, which mandate the assessment of risk characteristics of the underlying exposures of securitized positions.[12] These due diligence requirements address the perceived failure by investors to observe and monitor risks in securitized positions in the lead up to the GFC. Our findings on trading of CMBS by insurance companies in the aftermath of the pandemic indicate that institutional investors are capable of assessing risks to their securitization positions, also monitoring changes to these risks over time. These results also highlight how access to time-varying loan level information is beneficial for continuous risk assessment of asset-backed securities, both by investors and by policymakers.

However, the adjustment made by insurance companies in response to the build-up of these risks appears to be small, and insurance companies' portfolio of fixed assets is still exposed to a large share of CMBS with underlying office mortgages. In other words, in spite of investors' ability to assess and monitor risks to their securitized positions, frictions such as transaction costs and illiquidity could prevent these investors from significantly reducing their exposure to newly developing risks. This is particularly relevant in the context of insurance companies and MBS, as some post-crisis regulations have created incentives for the former to hold on to these assets (Becker, Opp and Saidi, 2022). Moreover, given the slow materialization of default risks arising from hybrid work, which depends on cash flow shocks, insurers could still face large losses to their portfolio arising from CRE mortgage default. The takeaway message is investors' ability to assess risks is no substitute for adequate capital requirements, which ensure insurers and other institutional investors can absorb losses to their asset portfolio, thereby internalizing threats to financial stability.

6.2. Commercial Real Estate Mortgage Default Risk

The COVID-19 pandemic led to a unprecedented change in work conditions, with hybrid work arrangements becoming prevalent and affecting real estate valuation. These changes

[12] See, for example Chapter 2, Article 5 EBA (2017).

in asset prices raised concerns about financial stability, as CRE serves as collateral for loans held by banks and these loands are included in CMBS. Until recently little evidence had been documented about how the sudden fall in demand for office space affects commercial mortgage default. Our study addresses this gap by showing how sensitivity to borrower income and the timing of cash flow shocks to the borrower matter for the transmission of lower office demand to credit risk.

There are several policy implications of the evidence of changes in default rates in response to CRE demand adjustments to depend on cash flow shocks to borrowers caused by contractual lease termination. First, our results inform the implementation of the revised banking standards ("Basel 3.1") that is currently being undertaken by prudential regulators around the world. These revised standards distinguish mortgages whether they are "*materially dependent on cash flows generated by the property*" (CRE20 in BCBS, 2022) for the purposes of capitalising their credit risk. For example, in its recent public consultation on implementing Basel 3.1, the UK's Prudential Regulation Authority (PRA) "proposes assign risk weights to mortgage exposures depending on whether repayment of the loan is materially dependent on the cash flows generated by the property."[13] From that view, our results provide evidence that supports this proposal for imposing of such an exposure classification based on cash flows. Furthermore, they highlight the value of property-specific contract information, in particular lease expiration dates, which can help policymakers identify mortgages materially dependent on cash flows. Second, our results suggest that examining aggregate delinquencies is not sufficient for gauging credit risk in CRE loans, as aggregate delinquencies fails to reflect post-COVID-19 lower office demand. This highlights the need for granular data for proper credit risk assessment. Specifically, they point to the value of tenancy agreement characteristics, in particular lease expiration dates, as a relevant determinate of borrower cash flow shocks. Third, our results are also relevant from a macro-prudential perspective. Since many tenancy agreements are due to expire in the next years (Table 1), the full effect of virtual work on aggregate mortgage default is yet to materialize, which might come with financial stability consequences. In short, monitoring of tenancy contractual characteristics should be useful for policymakers assessing credit risks in real estate mortgages.

[13] https://www.bankofengland.co.uk/prudential-regulation/publication/2022/november/implementation-of-the-basel-3-1-standards, accessed on 17 November 2023.

Differences in CRE mortgage characteristics are informative about how our results translate to non-securitized mortgages. For example, securitized mortgages are usually considered part of the prime market segment. If non-securitized mortgages are linked to properties of lower quality, we would expect the adjustment in response to work-from-home preferences to be stronger.[14] Moreover, to the extent rental markets in other countries have similar tenancy characteristics, we expect cash flow shocks to play a major role in how lower office demand affects CRE delinquencies and financial stability in other markets.

7. Conclusion

In this paper, we examine the role of cash flows shocks from renting out commercial properties for mortgage delinquencies, assessing the extent to which insurance companies monitor and are affected by these risks in securitized assets. Using rich data on commercial mortgages included in CMBS deals and insurers' asset portfolio, we document a link between borrower cash flow shocks triggered by lease expiration and office CRE loan default. This effect is stronger during the COVID-19 pandemic, caused by lower office demand due to work-from-home arrangements. Moreover, we show that insurers react to such collateral shocks in their CMBS portfolio by selling more exposed bonds before delinquency materializes. This suggests that—contrary to commonly held views—institutional investors do actively monitor underlying asset risk. Finally, this monitoring effort also makes insurers less reactive to observable risks in other assets, suggesting limited risk management capacity.

Our findings indicate that there is a build-up of materialized default risk once existing leases need to be rolled over, providing information as to which features of CRE loans are relevant to track such risks. Our findings also illustrate the limitations of policies requiring due diligence by institutional investors as means promote active risk management. While we make use of CMBS data from the U.S., these mechanisms should also take place in other markets and countries. Given the key role of insurers and mortgages for financial markets, our findings warrant further scrutiny, and monitoring, of the risks caused by lower office demand.

[14] CMBS loans are mostly non-recourse, with recourse more common in bank held loans (Glancy et al. (2023)). While recourse should reduce the likelihood of default, it should affect strategic default more than cash flow driven default. In that sense, default should be relatively *more* sensitive to cash flow shocks for recourse loans.

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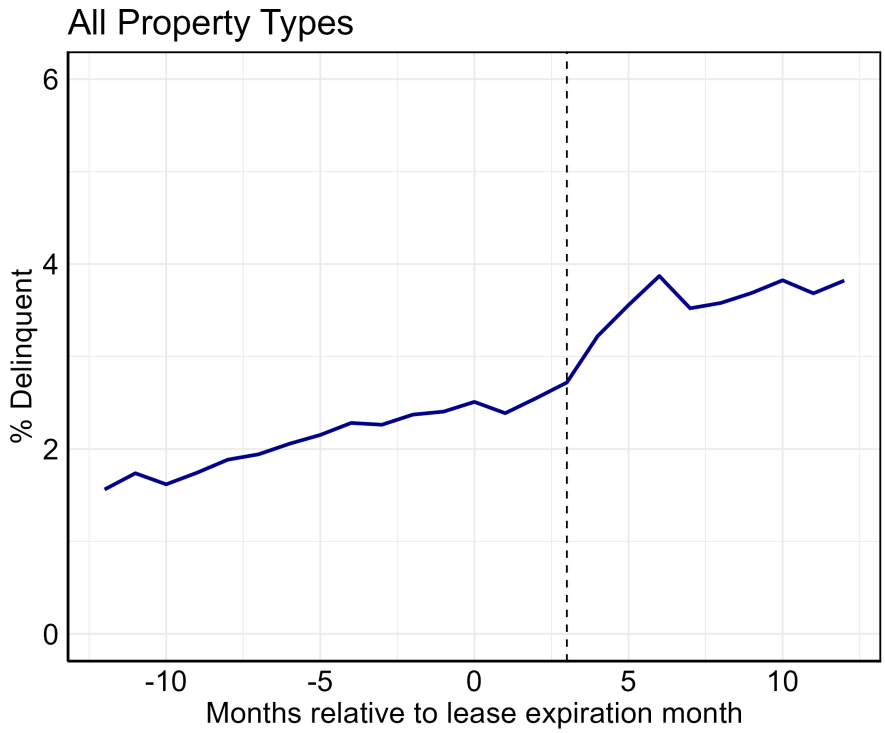
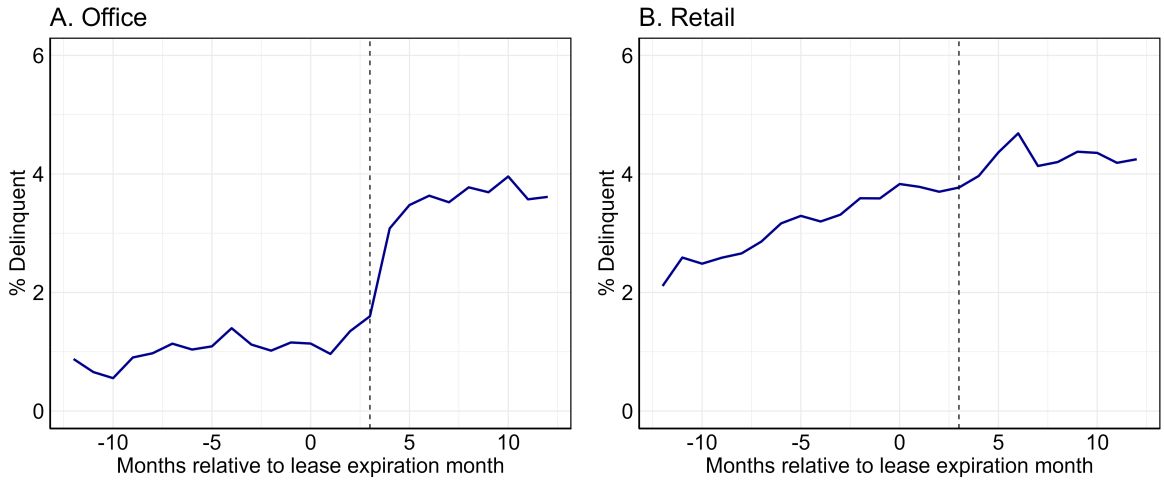
FIGURES

Figure 1: Changes in Delinquency—Lease Expiration Dates



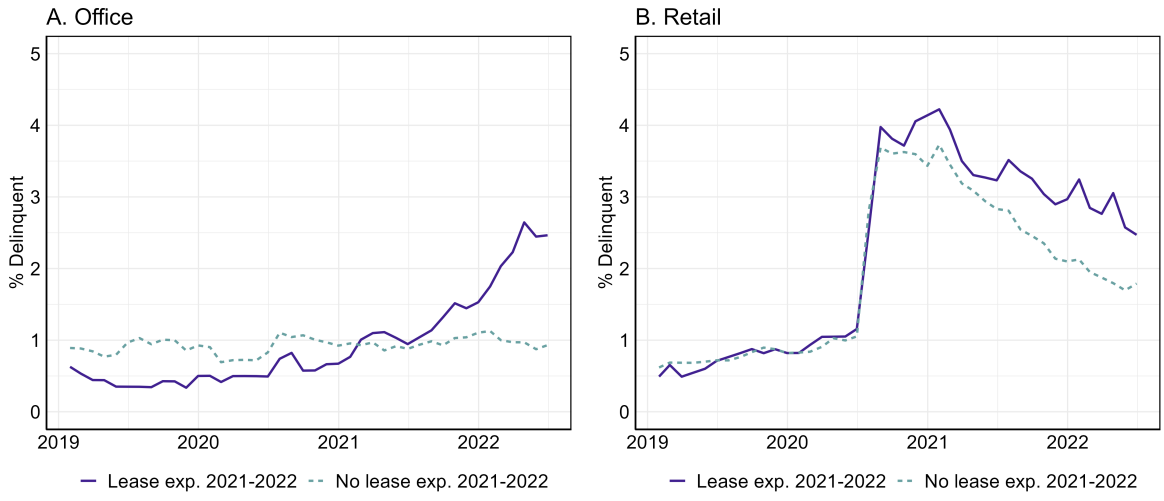
Notes: This figure shows average delinquency rates in each month relative to lease expiration, for properties with leases expiring between 2017 and June 2022. Delinquency is a dummy variable which equals 1 if a mortgage is at least 90 days past due. Sources: Trepp loan data and authors' calculations.

Figure 2: Changes in Delinquency—Lease Expiration Dates



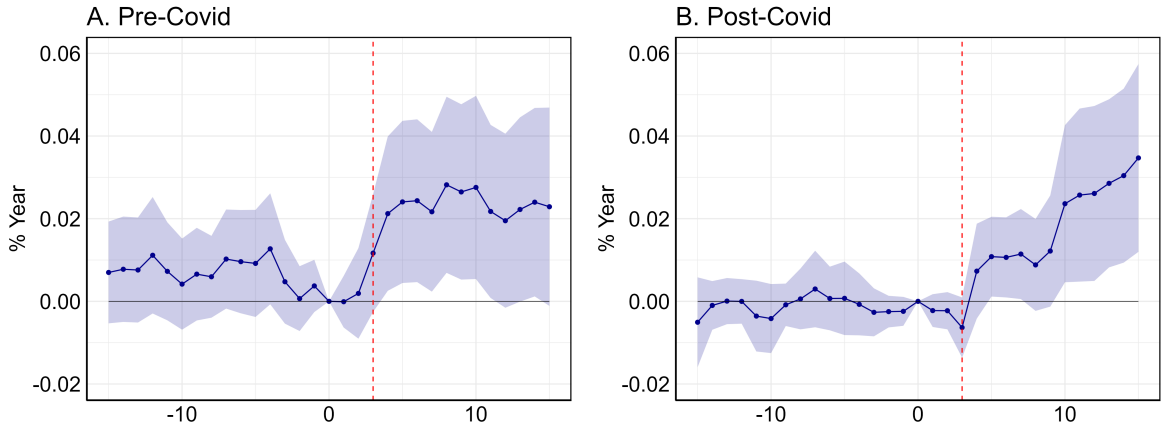
Notes: This figure shows average delinquency in each month relative to lease expiration, for properties with leases expiring between 2017 and June 2022. **Panel A** shows delinquency rates for properties classified as *Office*. **Panel B** shows delinquency rates for properties classified as *Retail*. Delinquency is a dummy variable which equals 1 if a mortgage is at least 90 days past due. Vertical line marks 3 months after lease expiration. Sources: Trepp loan data and authors' calculations.

Figure 3: Delinquency Rates—Mortgages with and without leases expiring within two year



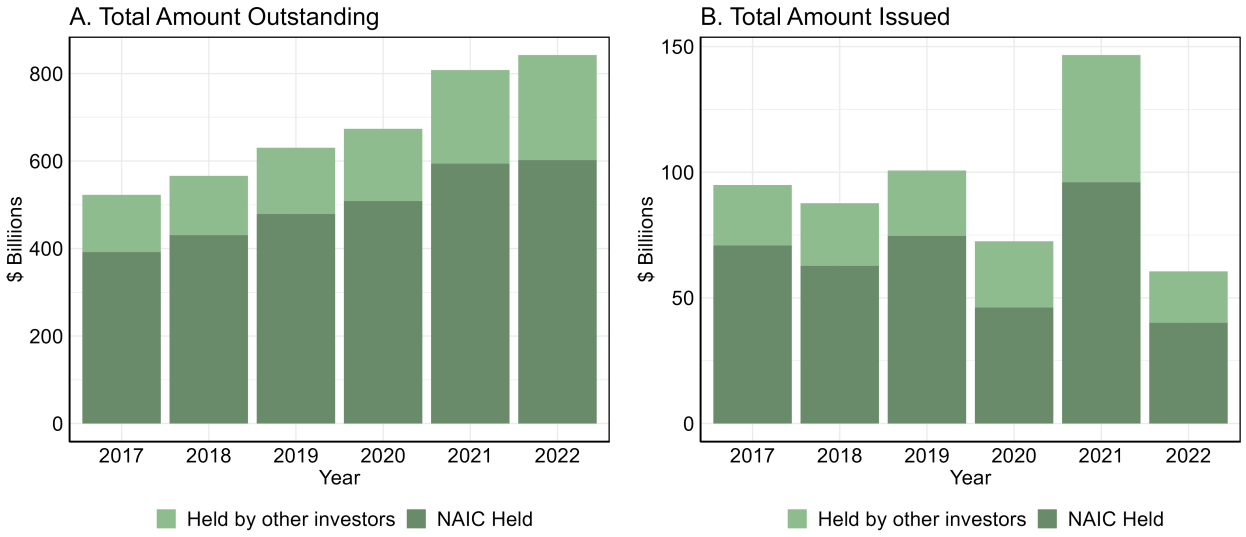
Notes: This figure shows average delinquency rates for mortgages *with* leases expiring in 2021-2022, and mortgages *without* leases expiring in these two years. **Panel A** shows delinquency rates for properties classified as *Offices*. **Panel B** shows delinquency rates for properties classified as *Retail*. Delinquency is a dummy variable which equals 1 if a mortgage is at least 90 days past due. Sources: Trepp loan data and authors' calculations.

Figure 4: Delinquency Rates Relative to Lease Expiration—Office WFH Sensitivity



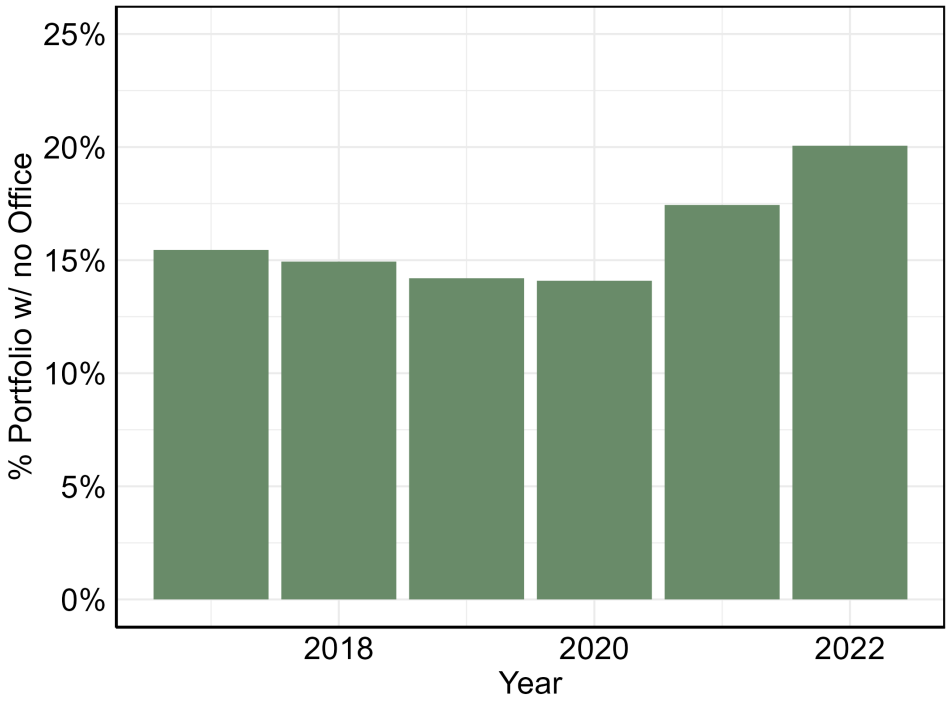
Notes: This figure shows the effects of lease expiration on delinquency rates of properties classified as *Office*. The δ_t estimates from Equation 3 show delinquency rates relative to the lease expiration month. Delinquency is a dummy variable which equals 1 if a mortgage is at least 90 days past due. Vertical line marks 3 months after lease expiration. **Panel A** includes all months before March 2020. **Panel B** includes all months after March 2020 (exclusive). Shaded areas correspond to the 95 percent confidence intervals around point estimates. Standard errors clustered at the loan level. Sources: Trepp and authors' calculations.

Figure 5: Insurance Holdings of CMBS



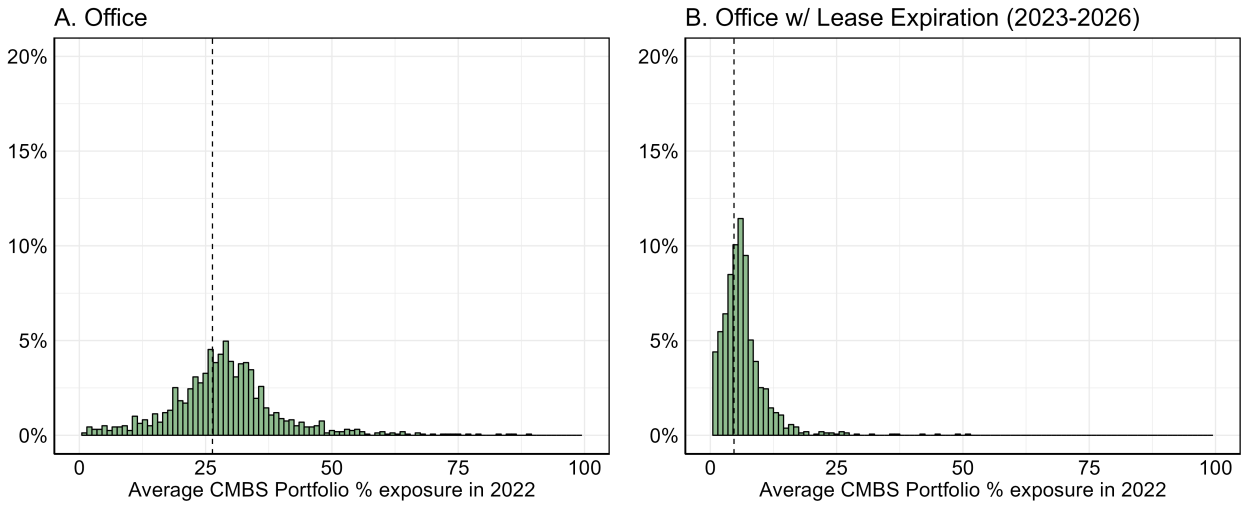
Notes: This figure shows the total amount outstanding (Panel A) and amount originated (Panel B) of private-label CMBS per year, differentiating between amount held by insurance companies and held by other investors. We identify holdings of insurance companies using NAIC Schedule D, Part 1. Both plots exclude interest-only and agency CMBS. Source: Trepp, NAIC, and authors' calculations.

Figure 6: % CMBS Portfolio Without Office Exposure



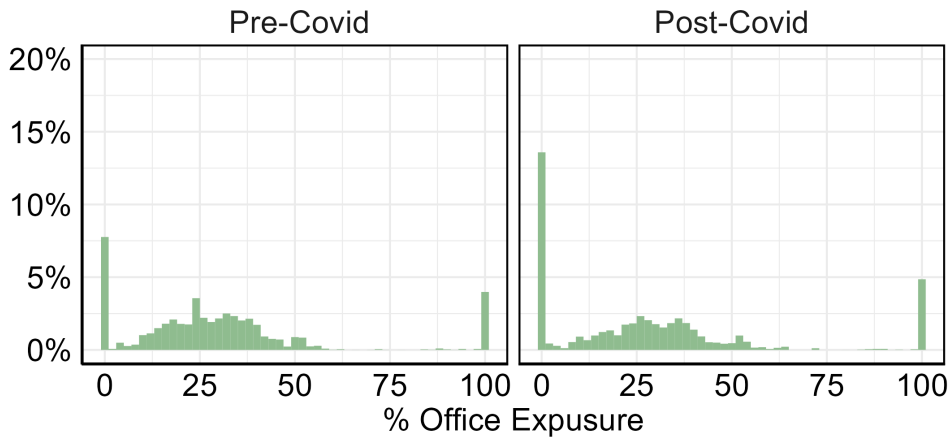
Notes: This figure shows the share of insurance companies private-label CMBS portfolio not exposed to *any* CRE mortgages linked to properties classified as *Office*. Share are calculated aggregating BACV for exposed and non-exposed CMBS, where exposure is defined as any percentage of the pool of mortgages used to finance office CRE. Source: Trepp, NAIC, and authors' calculations.

Figure 7: CMBS Bonds Held by Insurace Companies—Exposure to Offices



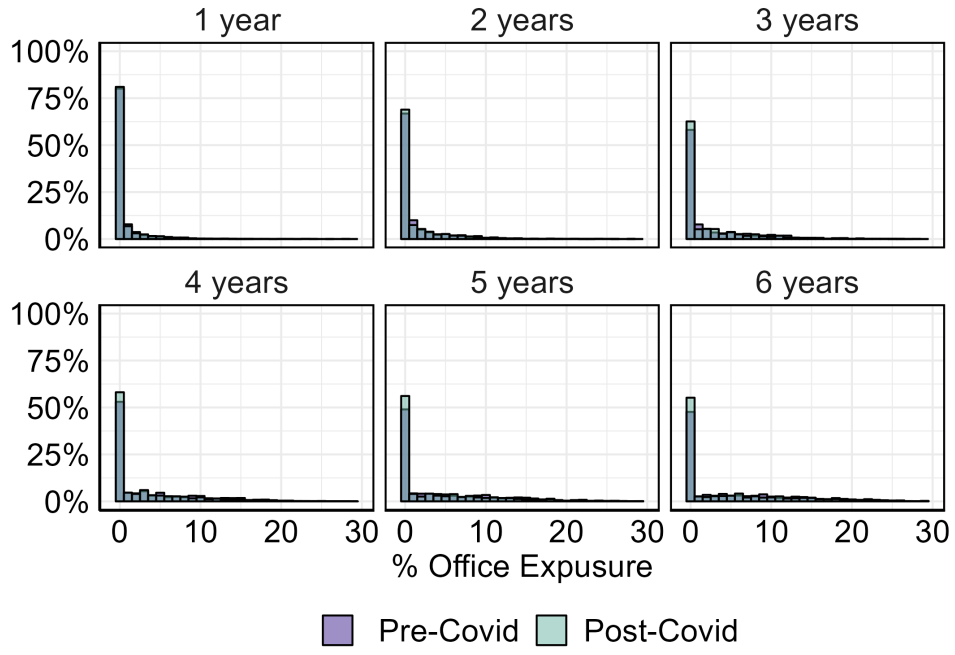
Notes: This figure shows the distribution of insurance companies' private-label CMBS portfolio to office-exposed CMBS. The left panel shows the distribution for any office exposure, and the right panel shows the distribution conditional on some mortgages having main leases expiring between 2023-2026. Source: Trepp, NAIC, and authors' calculations.

Figure 8: Distribution of Office Exposure—CMBS Acquired Before and After COVID-19



Notes: This figure shows the distribution of office exposures of CMBS acquired by insurance companies, before and after COVID-19. Percent exposure equals the amount of the pool of mortgages linked to office CRE. The left panel plots the distribution of office exposure for CMBS acquired between 2017-2019. The right panel plots the distribution of office exposure for CMBS acquired between 2020-2022. Width of each distribution bar equals 2%. Source: Trepp, NAIC, and authors' calculations.

Figure 9: Distribution of Office Exposure with short term Lease Expiration—CMBS Acquired Before and After COVID-19



Notes: This figure shows the distribution of office exposures with leases expiring within a certain time window of CMBS acquired by insurance companies, before and after COVID-19. Percent exposure equals the amount of the pool of mortgages linked to office CRE whose main lease agreement expires within that time window. Each panel plots the distribution of security exposures of CMBS acquired before and after COVID-19, for each time window. Source: Trepp, NAIC, and authors' calculations.

TABLES

Table 1: Summary Statistics

Panel A. All Properties	Mean	Median	Min	Max	N
Outstanding Balance	12,126,498.41	4,665,665.69	535.94	9,016,115,069.00	7081912
Floating Interest Rate	0.12	0.00	0.00	1.00	7081912
Delinquency (90 days)	0.01	0.00	0.00	1.00	7081912
Recourse Loan	0.01	0.00	0.00	1.00	7081912
Loan Term	228.39	120	1	515	7010744
Lease Expiration Year	2026	2024	2016	2099	747189
Largest Tenant % Sqr Ft	45.11	33.44	0.00	100.00	748523
Panel B. Office	Mean	Median	Min	Max	N
Outstanding Balance	35,592,214.49	17,545,061.17	6,760.18	3,000,000,000.00	276561
Floating Interest Rate	0.08	0.00	0.00	1.00	276561
Delinquency (90 days)	0.01	0.00	0.00	1.00	276561
Recourse Loan	0.02	0.00	0.00	1.00	276561
Loan Term	112.87	120	1	363	275307
Lease Expiration Year	2025	2024	2016	2099	209965
Largest Tenant % Sqr Ft	42.20	29.71	0.00	100.00	211306
Panel C. Retail	Mean	Median	Min	Max	N
Outstanding Balance	17,123,979.19	7,331,549.50	797.55	2,400,000,000.00	516328
Floating Interest Rate	0.02	0.00	0.00	1.00	516328
Delinquency (90 days)	0.02	0.00	0.00	1.00	516328
Recourse Loan	0.01	0.00	0.00	1.00	516328
Loan Term	123.63	120	1	360	506734
Lease Expiration Year	2027	2024	2016	2099	415663
Largest Tenant % Sqr Ft	45.68	34.52	0.00	100.00	417838

Notes: This table shows summary statistics from our sample of commercial real estate mortgages. **Panel A** includes summary statistics for all property types in the sample. **Panel B** includes summary statistics for properties classified as *Office*. **Panel C** includes summary statistics for properties classified as *Retail*. Source: Trepp and authors' calculations.

Table 2: Triple Differences—Lease Expiration Pre/Post COVID-19

	I_{jtr}^{D90}		
	(1)	(2)	(3)
Post Expiration	0.0131***	0.0132***	0.0140***
	(0.0029)	(0.0029)	(0.0034)
Post Covid × Post Expiration	-0.0029	-0.0029	-0.0013
	(0.0033)	(0.0033)	(0.0040)
Post Covid × Ind Office	-0.0162***	-0.0160***	-0.0216***
	(0.0019)	(0.0019)	(0.0031)
Post Expiration × Ind Office	0.0013	0.0014	0.0004
	(0.0062)	(0.0062)	(0.0068)
PostCovid × Post Expiration × Ind Office	0.0122*	0.0121*	0.0132*
	(0.0064)	(0.0064)	(0.0074)
Observations	751,294	751,294	751,294
R^2	0.42319	0.42324	0.57382
Within R^2	0.00208	0.00206	0.00300
Date fixed effects	✓		
Loan ID fixed effects	✓	✓	✓
Date × Floating fixed effects		✓	✓
Date × City fixed effects			✓

Notes: This table shows the effects of lease expiration on delinquency rates of different property types, before and after COVID-19. Each row corresponds to the coefficients γ and β_i from Equation 4. Estimates show the effect of lease expiration on delinquency rates, before and after COVID-19, for offices and all other property types. Delinquency is a dummy variable which equals 1 if a mortgage is at least 90 days past due. Standard errors clustered at the loan level in parenthesis. Significance Codes: ***: 0.01, **: 0.05, *: 0.1. Sources: Trepp and authors' calculations.

Table 3: Triple Differences and Occupancy %—Lease Expiration Before and After COVID-19

	inddlqs90								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PostExpiration	0.0185	0.0185	-0.0038	0.0129***	0.0130***	0.0128***	0.0119***	0.0120***	0.0118***
	(0.0175)	(0.0176)	(0.0340)	(0.0029)	(0.0029)	(0.0036)	(0.0030)	(0.0030)	(0.0037)
PostCovid × PostExpiration	0.0535*	0.0535*	0.0809	-0.0059*	-0.0059*	-0.0055	-0.0050	-0.0051	-0.0041
	(0.0294)	(0.0295)	(0.0638)	(0.0034)	(0.0034)	(0.0041)	(0.0034)	(0.0034)	(0.0041)
PostCovid × Ind Office	-0.0156***	-0.0156***	-0.0264**	-0.0155***	-0.0154***	-0.0210***	-0.0157***	-0.0155***	-0.0223***
	(0.0030)	(0.0030)	(0.0113)	(0.0025)	(0.0025)	(0.0042)	(0.0025)	(0.0025)	(0.0040)
PostExpiration × Ind Office	0.0488	0.0490	0.0720	-0.0046	-0.0046	-0.0056	-0.0035	-0.0034	-0.0044
	(0.0366)	(0.0367)	(0.0558)	(0.0064)	(0.0064)	(0.0070)	(0.0064)	(0.0064)	(0.0071)
PostCovid × PostExpiration × Ind Office	-0.0725**	-0.0727**	-0.1139	0.0169**	0.0168**	0.0207**	0.0162**	0.0161**	0.0205**
	(0.0363)	(0.0363)	(0.0721)	(0.0071)	(0.0071)	(0.0082)	(0.0071)	(0.0071)	(0.0082)
Full							-0.0058	-0.0057	-0.0036
							(0.0119)	(0.0119)	(0.0163)
PostCovid × Full							-0.0084**	-0.0084**	-0.0035
							(0.0034)	(0.0034)	(0.0056)
PostExpiration × Full							0.0131	0.0131	0.0079
							(0.0146)	(0.0146)	(0.0158)
Ind Office × Full							-0.0016	-0.0015	-0.0093
							(0.0131)	(0.0131)	(0.0180)
PostCovid × PostExpiration × Full							0.0544*	0.0544*	0.0626
							(0.0298)	(0.0298)	(0.0406)
PostCovid × Ind Office × Full							-8.32×10^{-6}	-0.0002	0.0038
							(0.0039)	(0.0040)	(0.0066)
PostExpiration × Ind Office × Full							0.0416	0.0415	0.0538
							(0.0325)	(0.0325)	(0.0364)
PostCovid × PostExpiration × Ind Office × Full							-0.0838**	-0.0839**	-0.1170**
							(0.0360)	(0.0360)	(0.0465)
Observations	135,346	135,346	135,346	611,679	611,679	611,679	747,025	747,025	747,025
R^2	0.44563	0.44565	0.71391	0.43901	0.43908	0.60674	0.43801	0.43807	0.58513
Within R^2	0.01021	0.01021	0.01239	0.00153	0.00150	0.00233	0.00283	0.00282	0.00373
Date fixed effects	✓			✓			✓		
Loan ID fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Date × Floating fixed effects		✓	✓		✓	✓		✓	✓
Date × City fixed effects			✓			✓			✓

Notes: This table shows the effects of lease expiration on delinquency rates of different property types, before and after COVID-19, for partial and full tenant ocupancy. Each row corresponds to the coefficients γ and β from Equation 4. Estimates show the effect of lease expiration on delinquency rates, before and after COVID-19, for offices and all other property types. We separately estimate this effect for the sample of partial and full tenant occupancy mortgages, and for the whole sample. Delinquency is a dummy variable which equals 1 if a mortgage is at least 90 days past due. Standard errors clustered at the loan level in parenthesis. Significance Codes: ***: 0.01, **: 0.05, *: 0.1. Sources: Trepp and authors' calculations.

Table 4: CMBS Bond Trading—Underlying Lease Expiration and Mortgage Delinquency

	I_{ijt}^{sold}			
	(1)	(2)	(3)	(4)
I_{jt}^{Exp}	0.0029	0.0017		
	(0.0029)	(0.0031)		
$I_{jt}^{Exp\ Office}$		0.0023		
		(0.0021)		
I_{jt}^{D}			0.0086***	0.0086***
			(0.0027)	(0.0028)
$I_{jt}^{D\ Office}$				0.0093**
				(0.0046)
Observations	176,824	176,824	176,824	176,176
R^2	0.63398	0.63399	0.63403	0.63366
Within R^2	1.7×10^{-5}	3.27×10^{-5}	0.00016	0.00025
Year × Insurer ID fixed effects	✓	✓	✓	✓
CUSIP × Insurer ID fixed effects	✓	✓	✓	✓
Year × Coupon Type fixed effects	✓	✓	✓	✓
Year × NAIC Designation fixed effects	✓	✓	✓	✓

Notes: This table shows the effect of exposure to underlying lease expiration and offices on the likelihood of sales of CMBS by insurance companies, as in Equation 5. I_{jt}^{Exp} and $I_{jt}^{ExpOffice}$ are dummies equal to 1 if bond j is exposed to mortgages whose main lease contracts expires up until one year ahead, for all properties and only offices, respectively. Standard errors clustered at the CUSIP level in parenthesis. Significance Codes: ***: 0.01, **: 0.05, *: 0.1. Sources: Trepp, NAIC, and authors' calculations.

Table 5: CMBS Trading Differences in Differences—Exposure to Lease Expiration

	I_{ijt}^{sold}					
Lease expiration horizon	$(\tau = 1)$	$(\tau = 2)$	$(\tau = 3)$	$(\tau = 4)$	$(\tau = 5)$	$(\tau = 6)$
$I_{jt}^{Exp(\tau)}$	0.0015	0.0010	0.0036	-0.0005	0.0029	0.0029
	(0.0033)	(0.0045)	(0.0052)	(0.0059)	(0.0069)	(0.0072)
$I_{jt}^{Exp\ Office(\tau)}$	0.0019	0.0029	0.0040	0.0055	0.0027	0.0034
	(0.0028)	(0.0031)	(0.0037)	(0.0045)	(0.0057)	(0.0066)
I_{jt}^{Office}	-0.0172	-0.0126	-0.0116	-0.0131	-0.0139	-0.0152
	(0.0207)	(0.0209)	(0.0209)	(0.0209)	(0.0207)	(0.0207)
Post Covid $\times$ $I_{jt}^{Exp(\tau)}$	0.0009	0.0100*	0.0168**	0.0070	0.0023	-0.0060
	(0.0048)	(0.0060)	(0.0070)	(0.0075)	(0.0085)	(0.0089)
Post Covid $\times$ $I_{jt}^{Exp\ Office(\tau)}$	-0.0008	0.0062	0.0066	0.0128**	0.0178**	0.0248***
	(0.0037)	(0.0042)	(0.0053)	(0.0061)	(0.0079)	(0.0087)
Post Covid $\times$ I_{jt}^{Office}	0.0238***	0.0141*	0.0094	0.0108	0.0097	0.0084
	(0.0070)	(0.0074)	(0.0075)	(0.0075)	(0.0077)	(0.0078)
Observations	219,731	219,731	219,731	219,731	219,731	219,731
R^2	0.60744	0.60754	0.60762	0.60757	0.60755	0.60757
Within R^2	0.00024	0.00049	0.00071	0.00057	0.00053	0.00058
Year $\times$ Insurer ID fixed effects	✓	✓	✓	✓	✓	✓
CUSIP $\times$ Insurer ID fixed effects	✓	✓	✓	✓	✓	✓
Year $\times$ Coupon Type fixed effects	✓	✓	✓	✓	✓	✓
Year $\times$ NAIC Designation fixed effects	✓	✓	✓	✓	✓	✓

Notes: This table shows the effect of exposure to underlying lease expiration and offices on the likelihood of sales of CMBS by insurance companies, as in Equation 6. $Post\ Covid_t$ equals 1 after 2019, $I_{jt}^{Exp(\tau)}$ and $I_{jt}^{ExpOffice(\tau)}$ are dummies which equal 1 if bond j is exposed to mortgages whose main lease contracts expires up until year $t+\tau$, for all properties and only offices, respectively. I_{jt}^{Office} is a dummy which equals 1 for any exposure to offices. Standard errors clustered at the CUSIP level in parenthesis. Significance Codes: ***: 0.01, **: 0.05, *: 0.1. Sources: Trepp, NAIC, and authors' calculations.

Table 6: Insurer CMBS Portfolio Exposure and Asset Sales

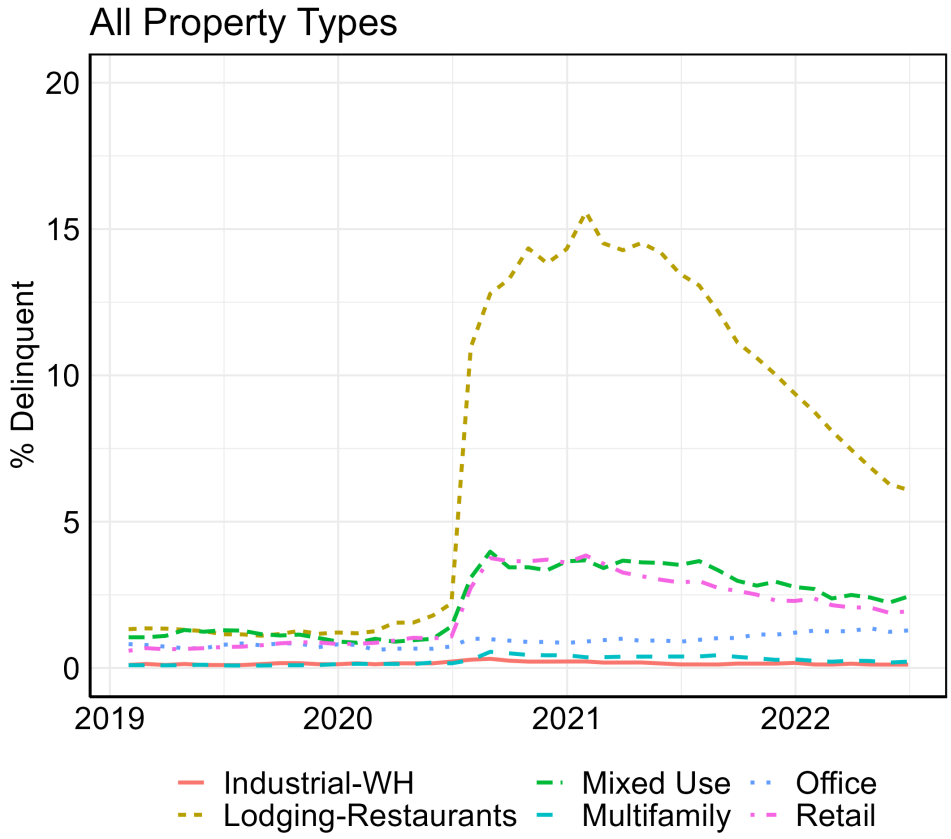
	I^{Risky}_{jt}		I^{sold}_{ijt}		$I^{Downgrade}_{jt-1}$	
	(1)	(2)	(3)	(4)	(5)	(6)
$I^{T}_{jt} \times T^{Office}_{it-1}$	-0.0008	-0.0016	-0.0017	0.0015	0.0102***	0.0103***
	(0.0021)	(0.0035)	(0.0035)	(0.0021)	(0.0040)	(0.0039)
$I^{T}_{jt} \times T^{Retail}_{it-1}$		0.0007	0.0006		-0.0070**	-0.0071**
		(0.0024)	(0.0024)		(0.0029)	(0.0029)
$I^{T}_{jt} \times T^{Lodging}_{it-1}$		0.0023	0.0040		-0.0051	-0.0057
		(0.0071)	(0.0070)		(0.0067)	(0.0068)
Post Covid $\times I^{T}_{jt} \times T^{Office}_{it-1}$	-0.0022	-0.0095***	-0.0093***	-0.0007	-0.0117**	-0.0117**
	(0.0021)	(0.0035)	(0.0034)	(0.0027)	(0.0046)	(0.0046)
Post Covid $\times I^{T}_{jt} \times T^{Retail}_{it-1}$		0.0078**	0.0076**		0.0094**	0.0095**
		(0.0031)	(0.0031)		(0.0038)	(0.0037)
Post Covid $\times I^{T}_{jt} \times T^{Lodging}_{it-1}$		0.0056	0.0042		0.0069	0.0085
		(0.0069)	(0.0069)		(0.0094)	(0.0093)
$I^{T}_{jt} \times T^{\%CorpBonds}_{it-1}$			0.0401***			-0.0076
			(0.0137)			(0.0115)
Post Covid $\times I^{T}_{jt} \times T^{\%CorpBonds}_{it-1}$			-0.0282*			0.0241
			(0.0146)			(0.0150)
Observations	7,091,153	7,091,153	7,091,153	5,605,453	5,605,453	5,605,453
R^2	0.71081	0.71082	0.71083	0.78171	0.78171	0.78171
Within R^2	0.00086	0.00090	0.00093	6.25×10^{-6}	1.55×10^{-5}	1.95×10^{-5}
Year× CUSIP fixed effects	✓	✓	✓	✓	✓	✓
CUSIP× Insurer ID fixed effects	✓	✓	✓	✓	✓	✓
Year× Insurer ID fixed effects	✓	✓	✓	✓	✓	✓

Notes: This table shows the effect of exposure to different types of collateral via CMBS holdings on the likelihood of sales of risky assets by insurance companies, as in Equation 8. $Post\ Covid_t$ equals 1 after 2019, T^{Prop}_{it-1} is the size of the exposure of insurance company i to property type $Prop$ in year $t-1$, and I^{T}_{jt} is a dummy which equals 1 if the bond is classified as $Risky$ or if it was downgraded in year $t-1$. $T^{\%CorpBonds}_{it-1}$ is the share of insurance company i fixed income portfolio invested in corporate bonds in year $t-1$. Standard errors clustered at the insurer level in parenthesis. Significance Codes: ***: 0.01, **: 0.05, *: 0.1. Sources: Trepp, NAIC, and authors' calculations.

Appendix

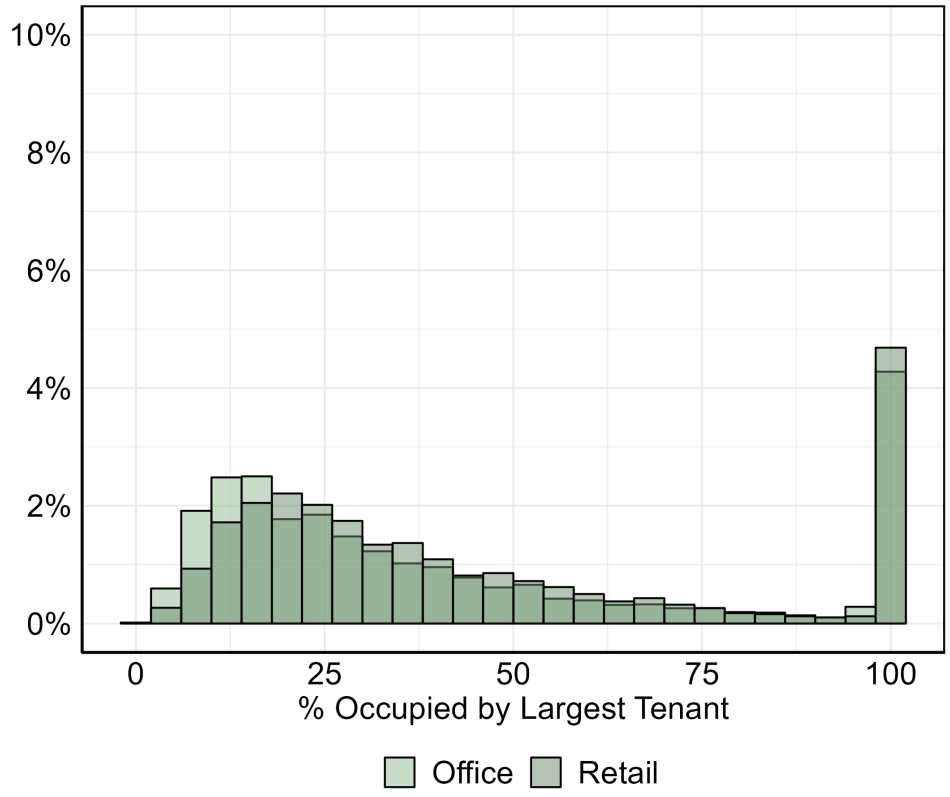
A. Additional Figures and Tables

Figure A.1: Delinquency Rates by Property Type



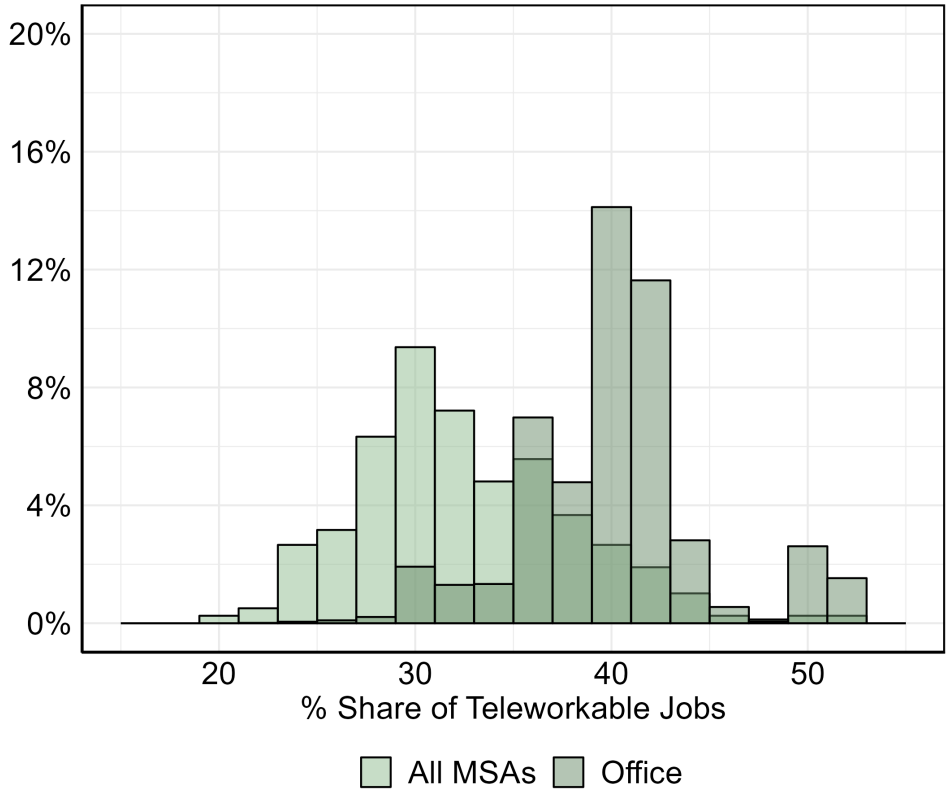
Notes: This Figure reports average delinquency for mortgages linked to different property types. Property types are defined as in Appendix B. Delinquency is a dummy variable which equals 1 if a mortgage is more than 90 days past due. Source: Trepp and authors' calculations.

Figure A.2: Distribution of % Occupancy by Largest Tenant



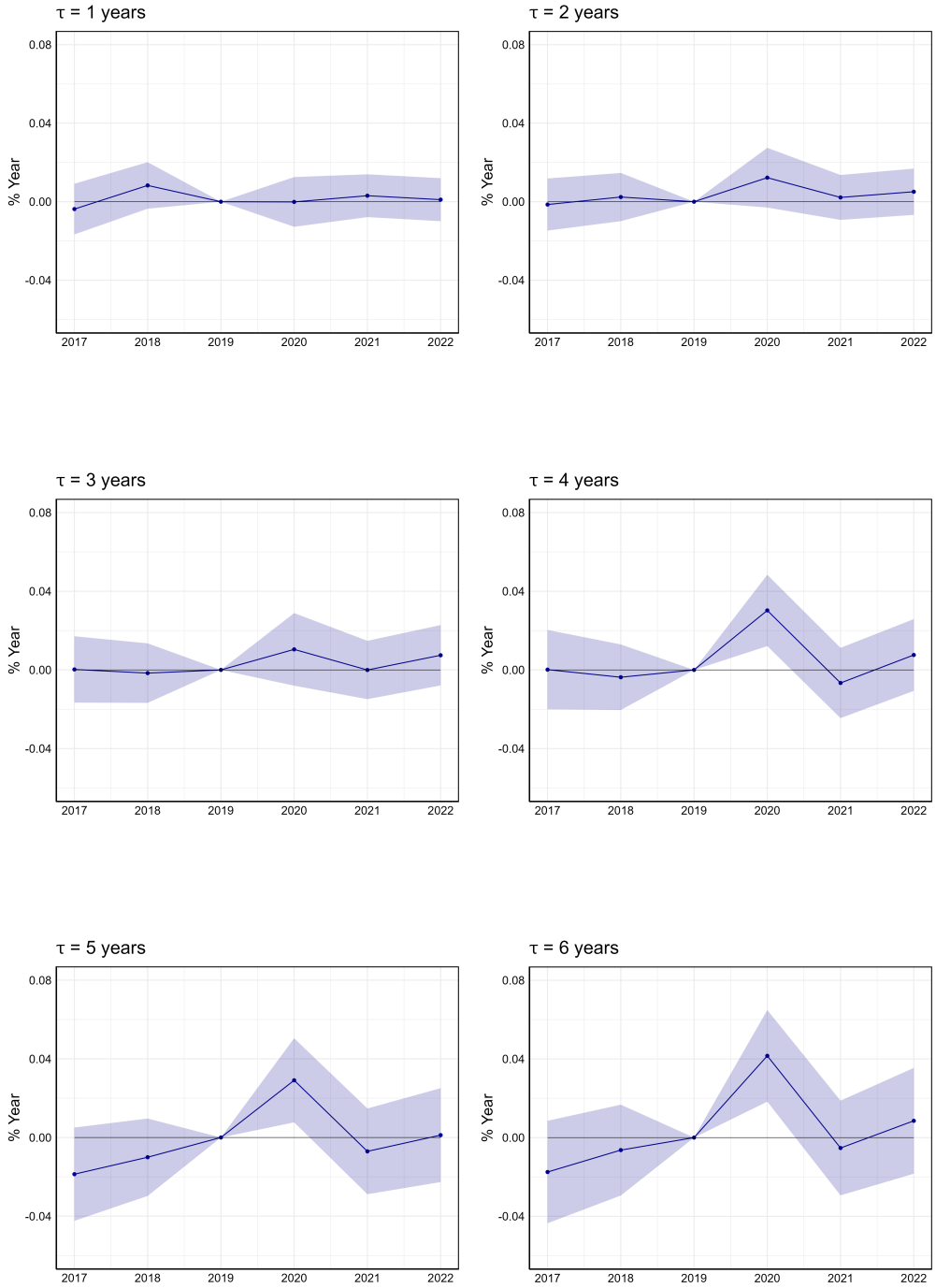
Notes: This figure shows the distribution of the % occupied by the largest tenant in the properties linked to CRE mortgages. We plot two distributions, with each distribution corresponding to one property type, either *Retail* or *Office*. Width of each distribution bar is 4%. Source: Trepp and authors' calculations.

Figure A.3: Distribution of % Teleworkable Jobs—All MSAs and Office Mortgages



Notes: This figure shows the distribution of the share of jobs in each MSA that can be performed from home, using the measure proposed by Dingel and Neiman (2020). We plot the distribution of all MSAs in the Dingel and Neiman (2020) dataset, and the distribution of the MSAs from the mortgages in the Trepp data, focusing on properties classified as *Office*. Width of each distribution bar is 2%. Source: Trepp and authors' calculations.

Figure A.4: Dynamic Difference-in-Differences: Trading of CMBS Exposed to Cash flow risks



Notes: Each plot shows the dynamic effect of exposure to underlying office lease expiration on the likelihood of sales of CMBS by insurers, as in Equation 7. $I_{jt}^{ExpOffice(\tau)}$ is defined as above and $D_{jt}^{ExpOffice(\tau)}$ are dummies equal to 1 if bond j is exposed to mortgages whose main lease contracts expires up until one year ahead and $\iota = t$. Source: Trepp, NAIC, and authors' calculations.

Table A.1: Property Types and Lease Expiration Information

Property Category	# without lease expiration	# with lease expiration	% with lease expiration
Healthcare-Nursing	464727	51	0.01
Industrial-WH	147055	53515	26.68
Lodging-Restaurants	208574	180	0.09
Mixed Use	66103	56571	46.11
Multifamily	5057710	831	0.02
Office	66596	209965	75.92
Other	223293	10413	4.46
Retail	100665	415663	80.50

Notes: This table shows the number of observations in our sample for which the lease expiration information is included, and the number of observations for which the lease expiration information is missing. Breakdown is provided by property types. Source: Trepp and authors' calculations.

B. Data Construction

Our data comes from two main sources: Trepp and NAIC. In what follows, we document the data cleaning procedures for each of the two data sources, and show how we obtain measures of exposure to cash flow shocks at the CMBS level.

Trepp CRE mortgage data. Mortgage data is informed at the loan level with frequency dictated by distribution dates (*ddate*). We use these distribution dates as our main date variables in the loan level analysis. In constructing our sample for the analysis, we exclude:

- Observations without *city* information;
- Observations with an outstanding balance lower than $ 500;
- Observations for which lease expiration is patchy, that is, when lease expiration information exists for certain months, ceases to be included, and is again included afterwards;
- Observations which have more than one broad property type associated with it in the year in our sample.

Furthermore, we use information from the variable *proptype*, informed by Trepp, to construct the broad property types which we use in our analysis. The variable *proptype* has a large number of stringers indicating the use of the property serving as collateral for each mortgages. We aggregate these strings into eight different property types: *Office*, *Retail*, *Multifamily*, *Mixed Use*, *Healthcare-Nursing*, *Lodging-Restaurants*, *Industrial and Warehouses*, and the residual category *Other*. Examples of how we bin different *proptype* into our broader property type category are:

- **Office** includes *proptype* strings such as "Office" "Office/Hdqr","Office Building" and "office properties";
- **Retail** includes *proptype* strings such as "Retail", "Retail Unanchored", "Retail Anchored" and "Retail Mall";

- **Multifamily** includes *proptype* strings such as "Multi-Tenant", "Multifamily" and "Multi-family";
- **Mixed Use** includes *proptype* strings such as "Mixed-Use", "Office/Warehouse", "Multifamily/Retail" and "Offc/Retail/Mltfmly";
- **Healthcare-Nursing** includes *proptype* strings such as "Nursing Home", "Medical Office", "Assisted Living" and "Medical Office";
- **Lodging-Restaurants** includes *proptype* strings such as "Hospitality", "Lodging Full Service", "Restaurant" and "Hotel";
- **Industrial and Warehouses** includes *proptype* strings such as "Industrial", "Self-Storage", "Warehouse" and "Industrial/warehouse".

The full list of strings and their respectively classification can be obtained upon request. Following this procedure, we obtain the loan level monthly panel summarized in Table 1.

B.1. CMBS and Insurer Level Exposure to Underlying Loan Characteristics

Since NAIC data is at annual frequency and Trepp data is at distribution date frequency (monthly), we follow an aggregation procedure to plug loan information into CMBS. Specifically, we collect deal level information corresponding to December of each year (and June for 2022, the last month in our sample from Trepp), and add this information to the bonds linked to each deal.

Specifically, let $TotAmt_{djt}$ denote the total amount outstanding of the pool of loans of deal d which is linked to bond j and $TotAmt_{djt}^{Offices}$ denote the same amount for loans linked to office properties. Then bond j's exposure to offices in year t is defined as $T_{jt}^{Office} \equiv \frac{TotAmt_{djt}^{Offices}}{TotAmt_{djt}}$. This exposure variable is used to construct dummy variables for positive exposure to offices using variables analogous to $TotAmt_{djt}^{Offices}$ that only include amount for loans with leases expiring within each τ horizon.

To obtain insurer level exposures, we calculate a weighted average exposure at the bond level (weighted by BACV), times the size of the portfolio of private-label CMBS for each insurer.

C. Identifying Active Sales and Acquisitions

The results in Section 5 rely on measures of active asset sales and acquisitions by insurers, obtained from NAIC Schedule D, parts 3 and 4. We identify active sales using a procedure similar to Becker, Opp and Saidi (2022). First, we use the information contained in the variable *name of the purchaser* to exclude entries with keywords associated with *maturity*, *redemption*, *repayment* and *default*, for example. We also impose the requirement of strict positive or negative value in the variable *realized gain(loss) on disposal*. Finally, we further exclude observations for which maturity dates coincide with the report date.

To classify active acquisitions, we identify a series of keywords for the *vendor* variable which contain information not associated with active acquisitions. These keywords include references to *exchange*, *capitalization*, *merger* and *transfer*, for example. The full list of keywords, alongside the R code, can be obtained from the authors upon request.