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Investor Sentiment and Prepayment Hazard: The Case of Multifamily MBS Loans

ABSTRACT

Rising property prices are one explanation for higher prepayments of commercial mortgages as borrowers refinance to take out equity or sell their assets. However, prices may be driven not only by fundamentals but also investor irrationality. We investigate the informative value of investor sentiment for prepayments of loans underlying CMBS. We employ Cox proportional hazard models to analyze a sample of 10,728 multifamily securitized loans for the period of 2001 to 2015. We find that, controlling for fundamentals, interest rates and loan characteristics, irrational investor sentiment is able to explain the exercise of the prepayment option by fixed and floating rate borrowers in times of increased property prices. The effect of irrational sentiment on prepayment hazard is robust to different sentiment measures as well as originator, geographic and deal characteristics. Our findings suggest that irrational investor sentiment is a source of information for lenders and CMBS investors interested in predicting prepayments.

KEYWORDS: CMBS, Prepayment Risk, Investor Sentiment, Multifamily, Cox Proportional Hazard Modeling

JEL CODES: D21, G21, G40, G41, R33

1. Introduction

Besides default, prepayment poses a key risk to commercial real estate lenders and investors in commercial mortgage backed securities (CMBS). Borrowers exercise their option to repay the outstanding loan balance before maturity if interest rates are sufficiently low and/or building values are sufficient high (Dierker, Quan and Torous, 2005; Kau et al., 1990). As a consequence, fundamentals such as interest rates or property market conditions have been found to predict prepayments of commercial mortgages by borrowers (e.g. Ambrose and Sanders, 2003; Huang and Ondrich, 2002). However, commercial real estate prices, returns and cap rates are not only affected by fundamentals, but also by irrational investor sentiment (Ling, Naranjo and Scheick, 2014; Clayton, Ling and Naranjo, 2009). As a consequence, we investigate the informative value of investor sentiment for the prepayment of mortgages. If borrowers take advantage of prices that are driven up by irrational investor optimism and subsequently sell their properties or refinance to take out equity, a higher investor sentiment is expected to predict higher mortgage prepayment rates. On the other hand, in times of irrational investor pessimism, prices are likely to be depressed and the ability of borrowers to sell their properties or refinance their mortgages is reduced, which is expected to result in lower prepayment rates.

In our study, we focus on prepayment risk as opposed to default risk in CMBS loans for the following reasons. Traditionally, default risk has received more attention than prepayment risk in the real estate literature (e.g. Ambrose, Sanders and Yavas, 2016; An et al., 2013; Fan, Sing and Ong, 2012; Seslen and Wheaton, 2010) as prepayment risk was considered to be negligible due to a variety of prepayment penalties in commercial mortgage contracts. However, prepayments occur as call-protection provisions by lenders vary in their effectiveness and prepayment risk cannot be entirely eliminated (Fu, LaCour-Little and Vandell, 2003). Prepayments have also been found to occur more frequently than defaults for most commercial property types (Ambrose and Sanders, 2003; Ciochetti et al., 2002). Additionally, prepayments have a larger impact on pricing fluctuations than defaults (Fu, LaCour-Little and Vandell, 2003).

In our empirical investigation, we focus on multifamily loans, which is in line with previous studies on commercial mortgages and/or CMBS (e.g. Pennington-Cross and Smith, 2017; Nothalf and Freund, 2003; Fu, LaCour-Little and Vandell, 2003; Huang and Ondrich, 2002; Kau et al., 1987). The advantage of multifamily MBS is that we can achieve a greater homogeneity with regards to the collateral underlying the mortgages, which minimizes the impact of confounding factors compared to more diverse commercial real estate types such as retail. Also, considering that government-sponsored enterprises (GSEs) set strict underwriting guidelines, the use of multifamily agency CMBS deals allows us to mitigate confounding effects stemming from underwriting standards and mortgage originator characteristics. Furthermore, Ambrose and Sanders (2003) find that for their sample, in which multifamily loans represent the largest proportion (42%), prepayments occurred more frequently than defaults. Multifamily as an asset class also experiences relatively stable cash flows and less volatile valuations over time (Corcoran, 2009). As a consequence, we consider multifamily to be uniquely suited to investigate the relationship of irrational investor sentiment and prepayments of mortgages underlying CMBS.

Using Cox proportional hazard models applied to 10,728 multifamily MBS loans for the period of 2001 to 2015, we find that irrational investor sentiment has informative value for the prepayment propensity of borrowers. In particular, in times of increased property prices, a higher sentiment (optimism) predicts higher prepayments for fixed and floating rate mortgages. The non-linear relationship of investor sentiment and prepayment hazard is in line with previous studies that provide evidence for an asymmetric relationship of investor sentiment and other variables such as market liquidity (Freybote and Seagraves, 2018) and the ex-ante risk premium (Beracha, Freybote and Lin, 2019). In our models, we control for loan, originator and deal-level characteristics, interest rates as well as macro-economic, property and capital market fundamentals. The predictive power of investor sentiment for prepayments is robust to different sentiment measure definitions.

We contribute to the CMBS literature (e.g. Ambrose and Sanders, 2003; Huang and Ondrich, 2002) by showing that irrational investor sentiment is an additional factor that can predict the exercise of the prepayment option by borrowers. Thus, prepayments by borrowers are not only based on factors such as interest rates or commercial real estate market fundamentals, but also investor irrationality. Our investigation has practical implications for lenders and CMBS investors as we identify investor sentiment as a factor that can help in forecasting prepayments as well as assessing and pricing prepayment risk.

The remainder of our manuscript is structured as follows. Next, we review the relevant literature to develop our theoretical framework and hypothesis. Then we present our data and methodology, which are followed by our results and conclusion.

2. Literature Review

Commercial real estate borrowers commonly repay their mortgages before maturity, i.e. exercise their call option, if interest rates are sufficiently low and/or building values are sufficiently high (Dierker, Quan and Torous, 2005; Kau et al., 1990). In particular, borrowers may take advantage of falling interest rates and refinance to, for example, reduce their mortgage payments. Ambrose and Sanders (2003) find that the market interest rate relative to the mortgage contract interest rate is an important predictor for prepayments in mortgages underlying CMBS.

Borrowers may also take advantage of rising property values and refinance to take out equity or sell the building. Previous studies have established that the amount of equity in the property underlying a mortgage explains prepayments (Ambrose and Sanders, 2003; Huang and Ondrich, 2002; Foster and Van Order, 1985). Ambrose and Sanders (2003) conclude that besides interest rates, equity and prepayment penalties are important for borrowers to exercise their call option and repay a loan prematurely. Huang and Ondrich (2002) find that property market fundamentals such as rental price growth and vacancy rates have an impact on the prepayment rates of FHA multifamily mortgages. Property market conditions have not only been found to be important for explaining borrower behavior with regards to prepayment but also default (An et al., 2013).

However, the characteristics of commercial real estate markets, such as segmentation and variable liquidity (Fisher et al., 2003), result in informational inefficiencies. To complement incomplete fundamental information, commercial real estate investors have been found to rely on sentiment and the opinion of others in their decision-making (Gallimore and Gray, 2002). As a result, investor sentiment affects commercial real estate market returns (Marcato and Nanda, 2016; Ling, Naranjo and Scheick, 2014), cap rates (Clayton, Ling and Naranjo, 2009), market liquidity (Freybote and Seagraves, 2018), the ex-ante risk premium required by investors (Beracha, Freybote and Lin, 2019) and the sentiment of other investors (Freybote and Seagraves, 2017). The importance of sentiment for investment decisions and asset pricing in commercial real estate markets also has implications for securitized real estate markets. Investor sentiment in the commercial real estate market has been found to have an effect on REIT returns (Das, Freybote and Marcato, 2015) and REIT bond yields (Freybote, 2016).

Considering that commercial real estate prices are not only driven by fundamentals but also investor irrationality, we hypothesize that investor sentiment allows to predict CMBS loan prepayment rates. If irrational investor optimism drives up prices and reduces cap rates, borrowers are more likely to refinance their mortgages to take out equity or sell their properties. In an option-theoretic context, if irrational optimism in the commercial real estate market is high and drives up asset prices, the call option of borrowers is likely to be in the money. The more the call option is in the money, the more likely is the borrower to prepay (Ciochetti et al., 2002). On the other hand, if irrational pessimism depresses prices and increases cap rates, borrowers are less likely to be able to sell their property or refinance to take out equity, which reduces their prepayment propensity. Thus, the higher (lower) irrational investor sentiment is in the multifamily real estate market, the more likely are borrowers to repay (not repay) their mortgages prematurely and the higher (lower) are prepayment rates.

3. Data

We filter the Bloomberg CMBS database for agency deals with vintages between 2001 and 2015. Our rationale for selecting this period is that it enables us to capture a full market cycle. Agency CMBS deals represent securities issued by government-sponsored enterprises (GSEs) such as the Federal National Mortgage Association (Fannie Mae) or Federal Home Loan Mortgage Corporation (Freddie Mac). GSEs obtain and securitize multifamily mortgages in two ways. First, private lenders originate loans ("Agency loans", hereafter) based on criteria set by these agencies. Lender interest in these loans, in terms of prepayment, is protected by several means such as yield maintenance (YM), prepayment lockout, defeasance or prepayment penalties. Second, Fannie Mae purchases loans through its Delegated Underwriting Services (DUS) program. The agency has identified 25 mortgage lenders who must adhere to rigorous underwriting standards. DUS loans are subject to stringent call protection, primarily through yield maintenance. To ensure the alignment of lender and agency interests, DUS lenders must sign a risk-sharing agreement with Fannie Mae for each loan until it matures. In case of non-DUS loans, lenders share limited or no risk.

After filtering for multifamily CMBS deals that originated between 2001 and 2015, the database generates a list of 248 deals. For each deal, we download a separate file which records the deal performance over time. Further, we apply a software script to summarize each file separately for variables such as the number of tranches, the range of loan maturities and the range of loan principals (original balances). The script also consolidates the deal summaries into one file.

From these deals, we separately extract data for individual loans and properties. We apply property identification to match the two datasets, thus providing us with a sample of 11,905 loans. The matched data set of property and loan characteristics is further enriched with deal summary information that we obtained in the earlier step. After a manual review of the dataset generated, we exclude loans with multiple properties (portfolios). Further, from these deals we select those identified as "Agency" or "DUS" type CMBS deals. The rest of the deals are specified as other types such as "Conduit" or "Single Asset Single Borrower" (SASB). We also remove observations where the origination date is incorrectly entered (i.e. the origination date is after the prepayment date). This leaves us with 179 deals and 10,728 corresponding loans in the sample with each deal pooling between 1 to 233 multifamily loans[1].

Figure 1 provides an overview of agency and DUS deal originations in our sample over the period of 2001 to 2015. The securitization of multifamily loans by GSEs has witnessed a steady growth since 2001. The securitization peaked in 2006 and declined during the global financial crisis. Since the end of the 2007 to 2009 financial crisis, agency CMBS deals have generally shown an upward trend. The majority of loans in our sample was originated after 2010.

[Insert Figure 1 here]

Table 1 presents an overview of loan originations and prepayments separated by refinancing loans and new purchase mortgages (fixed rate and floating rate) in our sample as well as the average annual Situs RERC sentiment score for apartments. For our sample, most prepayments occurred between 2010 and 2013 (fixed rate mortgages) and 2011 and 2014 (floating rate mortgages).

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[1] In the Bloomberg database, a known issue is related to mis-specifying the status of some loans. For example, if a loan is prepaid before its maturity, its status may erroneously change from "Prepaid" to "Matured" when observed after the pre-decided maturity date. However, in our sample we have only 54 loans with the "matured" status. All these loans matured in 2015 and were originated between 2010 to 2013 with an average maturity of nearly four years. Besides, none of these loans was fully amortizing. Three of these loans matured in less than 3 years and are candidates for erroneous recording. However, this is a very small percentage (0.003%) and is not likely to significantly alter the results.

[Insert Table 1 here]

The dependent variable in our investigation is the event of prepayment (*PREPAID*). Hereby, loans that were repaid at maturity are not considered "prepaid" as they do not represent an unanticipated hazard. In our sample, nearly 10% of all mortgages were repaid before maturity. This prepayment rate is in line with Ambrose and Sanders (2003), who report an 8% prepayment rate for loans underlying CMBS deals. As shown in Table 2, prepayment rates in our sample are substantially higher for floating-rate loans (16%) than fixed rate loans (7%).

In our analysis, we control for loan-specific variables. Loan-level variables included are loan characteristics such as loan to value ratio (*LTV.L*) and debt service coverage ratio (*DSCR.L*) as well as controls for the loan originator and location (state). In our analysis, we distinguish between floating and fixed rate mortgages. Evidence from the housing market suggests that borrowers of fixed and adjustable rate residential mortgages differ from each other to some degree (Chen and Stafford, 2019). Philips, Rosenblatt and Vanderhoff (1996) find that fixed and adjustable rate single-family borrowers differ in their mortgage termination behavior. We furthermore include variables capturing loan amortization characteristics and prepayment protections. We also include continuous and binary variables controlling for CMBS deal-level characteristics.

Table 2 presents an overview of the variables included in our analysis as well as their respective summary statistics. We provide descriptive statistics for the full sample and separated by mortgage type (fixed rate vs. floating rate). The majority (73%) of CMBS loans in our sample are fixed-rate (7,800) and the remaining 27% (2,928) are floating-rate mortgages. A small number of loans are part of DUS deals (430) and all DUS loans are fixed-rate.

[Insert Table 2 here]

Our independent variable of interest is the sentiment of multifamily investors. We follow previous studies investigating commercial real estate investor sentiment and use the Situs RERC sentiment measure as proxy (Beracha, Freybote and Lin, 2019; Freybote and Seagraves, 2018; Das, Freybote and Marcato, 2015; Ling, Naranjo and Scheick, 2014; Clayton, Ling and Naranjo, 2009). This measure is based on an item in a quarterly survey conducted by Situs RERC, which asks commercial real estate market participants to rank investment conditions in different typological markets from 1 (poor) to 10 (excellent). To capture the sentiment of multifamily investors, we obtain the Situs RERC investment conditions survey item for the apartment market over the period of Q1/2001 to Q4/2015.

However, our Situs RERC sentiment measure (*RERC*) reflects fundamental and non-fundamental factors. We therefore also derive a measure that only reflects the non-fundamental or irrational component of sentiment. To extract investor sentiment that is not based on fundamentals, we regress our sentiment measure onto variables capturing macro-economic, capital and property market conditions as shown in Equation 1. This approach is in line with previous studies that orthogonalize sentiment measures and fundamentals (Das, Füss, Hanle, and Rüss, 2020; Ling, Naranjo and Scheick, 2014; Clayton, Ling and Naranjo, 2009). In particular, we account for conditions in the apartment market by including the multifamily property price index from Real Capital Analytics (*CPPI*). Debt capital market conditions are reflected by the term structure (*TERM*), defined as yield spread between a 10-year Treasury bond and the 3-month Treasury bill, as well as the credit default spread (*DEFAULT*), defined as the yield spread between corporate bonds rated BAA by Moody's and the 3-month Treasury bill. We also include a measure of perceived credit tightness for commercial loans (*CRTIGHT*) as reported by Senior Loan Officer Survey. The market average loan to value ratio (*LTV.M*) provided by NCREIF controls for the equity stake in leveraged multifamily assets. Last, we account for conditions in the stock market and general economy, by including the return on the S&P 500 index (*SNP500*) and the implied stock market volatility based on the CBOE volatility index (*VIXSP500*).

$$RERC = \alpha + \beta x FUNDAMENTALS + \varepsilon \qquad \textbf{(1)}$$

Here, β is a 1xk matrix of coefficients and *FUNDAMENTALS* is a kx1 matrix of the time-varying fundamentals. The fitted value is the component of investor sentiment (*RERC*) that is explained by fundamentals. The residual ε serves as or proxy for sentiment that is not explained by fundamentals (*SENT.IRR)*.

In our empirical analysis, we control for financial conditions that affect prepayment decisions of borrowers. As macro-economic and financial variables are highly correlated, we create a financial index or factor (*MACROF*) by employing principal component analysis to macro-economic, capital market and property-market specific variables (*CPPI, TERM, DEFAULT, LTV.M, CRTIGHT, SNP500* and *VIX500*). This approach is in line with previous studies that use highly correlated commercial real estate market variables (e.g. Hartzell, Kallberg and Liu, 2005), investor sentiment measures (Ling, Naranjo and Scheick, 2014) or location-specific variables (Malpezzi and Shilling, 2000) in their analysis. The derivation of *MACROF* is also in line with other financial indices that are based on different fundamental variables such as the Goldman Sachs Financial Conditions Index (GSFCI) or the St. Louis Fed Financial Stress Index (STLFSI)[2]. Financial stress indices have been shown to be effective in capturing conditions in capital markets that have an impact on the macro-economy (Fink and Schüler, 2015; Hubrich and Tetlow, 2015) and firms. However, compared to these more general financial indices, our *MACROF* index captures property market, capital market and economic conditions that are of relevance to multifamily investors. Risk measures such as *VIXSP500* load positively onto *MACROF* while return measures such as *SNP500* load negatively onto it. Thus, a higher (lower) *MACROF* suggests deteriorated (improved) financial and economic conditions[3].

Considering that interest rates are an important explanation for the exercise of the prepayment option by borrowers (Ambrose and Sanders, 2003), we also include the average interest rate on multifamily loans in the NCREIF index (*INTRATE*) in our empirical investigation. This variable is estimated based on leveraged return cash flows from NCREIF[4]. Additionally, we expect that the decision of borrowers to sell their assets or refinance differs across periods of high and low property prices and interest rates (i.e. it varies across interest rate regimes and property market cycles). As a consequence, we create *MFGROWTH* and *INTGROWTH*, which are coded 1 if the *CPPI* (*MFGROWTH)* or the *INTRATE* (*INTGROWTH*) respectively have increased in the quarter of analysis compared to the previous quarter.

Table 3 presents the descriptive statistics for our variables. The mean Situs RERC sentiment (*RERC)* is 6.26, which, considering the range of 1 (poor) to 10 (excellent) suggests that investors on average considered investment conditions in multifamily somewhat good, i.e. were on average somewhat optimistic.

[Insert Table 3]

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[2] For more information, please visit: https://research.stlouisfed.org/publications/economic-synopses/2017/11/03/financial-conditions-indexes

[3] This principal component explains 57% of variation. The loadings are as follows: CPPI(-0.8), SNP500(-0.3), DEFAULT (0.8), CRTIGHT (0.8), VIXSP500 (0.9), LTV.M (0.5), TERM (0.6)

[4] We extract aggregated cash flow data from NCREIF's "leveraged cash flow" database. Interest rate is estimated by annualizing the quarterly estimate. The quarterly interest rate equals the interest payment over the loan balance at the beginning of a quarter.

4. Methodology

In our empirical investigation, we first employ non-parametric survival functions, which describe the proportion of loans that survive before a certain event ('hazard') occurs (over the lifetime of loans). Survival functions, primarily the cross-sectional analysis of duration data, have been used in previous studies investigating -amongst others- CEO turnover (Jenter and Kanaan, 2015), firm takeover (Malmendier, Opp and Saidi, 2016) and survival of equity positions in a firm (Bradley, Pantzalis and Yuan, 2016). A number of studies apply survival functions to model the hazard of default or prepayment in mortgages (Liu and Sing, 2017; Ambrose, Sanders and Yavas, 2016; Chen and Deng, 2013). The prepayment of a loan, default or special servicing represent a hazard. In the survival function methodology, the data of a particular loan ceases to exist when the loan is met with the hazard. Therefore, loans, which matured, defaulted or survived until the date of data collection are "censored" by the statistical package after their most recently recorded survival duration. In our empirical analysis, we only focus on mortgage prepayments as hazard.

Suppose, t represents a point in the lifetime of a loan and T denotes the survival duration of a loan. Let $f(t)$ and $F(t)$ be the probability density function (pdf) and cumulative distribution function (cdf) of T (i.e. $\frac{dF(t)}{dt} = f(t); or\ F(t) = \int_0^t f(x)dx$). Although t is recorded on discrete intervals (per-day, in our case), we can assume it to be a continuous function. Therefore, $F(t) = P(T<t)$ is the probability that the prepayment hazard has occurred by its age t. On the contrary, the survival function $S(t)$ denotes the probability that the loan survived beyond its age t. Therefore,

$$S(t) = P(T \geq t) = 1 - F(t) = \int_t^{\infty} f(x)dx \qquad \textbf{(2)}$$

This also implies that

$$\frac{dS(t)}{dt} = -f(t) \qquad \textbf{(3)}$$

In other words, $S(t)$ is the probability that the loan was not prepaid until it reached the age t. We start our analysis with baseline survival functions, in particular the Kaplan-Meier curves plots, which plot the survival rate of individual loans in the sample over their respective life.

The hazard function is the instantaneous probability for the hazard (prepayment) to occur at age t given the loan survives until then:

$$h_0(t) = \lim_{dt \to o} \frac{P(t \leq T < t+dt \mid T \geq t)}{dx} \qquad \textbf{(4)}$$

By definition, the condition in the equation denotes the survival probability $S(t)$ and the conditional probability in the numerator is $f(t)dt$. Therefore, $h_0(t) = f(t)/S(t)$.

From Equation (2) and (3), we derive equation 5:

$$\Rightarrow h_0(t) = -\frac{d(S(t))}{S(t)} = -\frac{d}{dt}\{log[S(t)]\} \qquad \textbf{(5)}$$

In the baseline model, h_0 can be derived by observing the proportion of loans that survives in consecutive time intervals, after accounting for censored observations. However, it assumes that the hazard is purely a function of age and does not depend on other covariates. The Cox Proportional Hazard model provides the possibility to include covariates (*X*) by positing the hazard function as an enhancement of the baseline hazard function:

$$h(t \mid X) = h_0(t)e^{\beta X} \qquad \textbf{(6)}$$

Here *X* is a *jx1* matrix of covariates including investor sentiment, β is an 1xj matrix of corresponding coefficients and *j* denotes the number of covariates. The non-parametric baseline hazard function (h_0 *(t))* need not be specified whereas the parameters (β) have to be estimated using partial likelihood estimators. For two individuals (say, l and m), the hazards will be proportional at any time *t* (i.e. $h_l(t)/h_m(t)$ is a constant). Therefore, the Cox Proportional Hazard model is said to be semi-parametric proportional hazard model.

5. Results

Figure 2 depicts the non-parametric baseline survival curve for the complete sample of agency multifamily MBS loans. Prepayment rates are almost zero for the first several months as call protection measures are the most stringent during this time period. Survival probability declines almost linearly between, approximately, the second and fifth year. The loans are "seasoned" during this time period after which the survival curve continues to decline more gently. However, Figure 3 suggests that the prepayment behavior of borrowers differs between fixed and floating rate loans, which is similar to previous findings from the residential mortgage market (e.g. Philipps, Rosenblatt and Vanderhoff, 1996). Floating rate loans start prepaying much sooner, usually when they are about 15 months old. One explanation is that floating rate loans, compared to fixed rate loans, generally have fewer prepayment protection measures, if any at all. The survival rate falls drastically during the first three years. Floating rate mortgages season afterwards until the 8^{th} year in their life after which the survival probability starts falling again. Fixed-rate loans exhibit a different pattern. They usually are not met with the prepayment hazard until approximately year 3 after which the survival rate falls along a gentle slope. However, the period of seasoning is longer, and the survival rate flattens for a shorter period (between years 8 and 10) after which it starts to fall. Figure 4 presents the survival rate curves for DUS and other agency loans. The curves suggest that the prepayment patterns vary between these types of mortgages. Analogously, the survival curves for new purchase and refinance mortgages in Figure 5 suggest that the prepayment behavior of borrowers differs across different mortgage purposes.

[Insert Figure 2 here]

[Insert Figure 3 here]

[Insert Figure 4 here]

[Insert Figure 5 here]

While survival curves provide a broad understanding of the overall survival trends for loans in our sample, they do not provide insights into the informative value of investor sentiment for prepayments. In the next step of our analysis, we run Cox proportional hazard regressions for the model as shown in Equation 6. Considering the number of variables in our model and to ensure reader-friendliness, we do not report the results for control variables such as originator and state dummies in our tables. Using a baseline model with deal, originator, state and mortgage characteristics but without fundamentals and sentiment variables (*results not reported*), we find that deal characteristics, with the exception of number of tranches (*D_TRANCHES*)*,* do not have an impact on the prepayment hazard. In particular, the number of tranches has a significantly negative coefficient, which suggests that loans belonging to a deal with a larger number of tranches prepay significantly less. A large number of tranches in a deal signifies a more sophisticated deal (An et al, 2013) where the loan underwriting may be superior, leading to less occurrence of prepayment in the underlying loans. Several of the originator and location dummy variables are also statistically significant in our baseline model, which suggests that there may be a clustering in prepayment behavior based on the borrower-lender relationship and/or geographic region. This is in line with previous studies that find the originator of a loan to matter with regards to the quality of a mortgage (Black et al., 2012; An, Deng and Gabriel, 2011; Titman et al., 2010) and the location of a collateral to have an impact on prepayment risk (Ambrose and Sanders, 2003). Additionally, a larger number of call protections (*PROTECT*) have a negative impact on the prepayment propensity of fixed rate borrowers.

Table 4 presents the results of our Cox proportional hazard regression with the fundamental factor (*MACROF*) and Situs RERC sentiment measures (*RERC* and *SENT.IRR*). We present our results separated by loan type considering the difference in prepayment behavior of fixed rate and floating rate borrowers as shown in Figure 3.

The effect of loan characteristics on prepayment propensity varies between fixed-rate and floating-rate mortgages. In particular, mortgage purpose (acquisition and refinance), interest-only or partial interest-only loan type, as well as LTV and DSCR have an impact on the prepayment propensity for floating rate mortgages while only *Partial IO* has an impact on the prepayment propensity for fixed rate mortgages.

The effect of financial conditions (*MACROF)* on prepayment propensity is consistent across different mortgage types. In particular, *MACROF* has a significantly positive relationship with the prepayment hazard. Considering that a higher (lower) *MACROF* indicates deteriorated (improved) financial conditions, our results suggest that deteriorating financial conditions lead to higher prepayments by multifamily borrowers. One explanation for this effect may be divestment strategies by some investors with regard to certain multifamily assets and markets, as financial conditions deteriorate. In times of increased property prices (*MFGROWTH*), fixed and floating rate borrowers are less likely to prepay their mortgages as suggested by the negative coefficient on *MFGROWTH*. The negative coefficient on the interaction effect of increased property prices and financial conditions (*MACROFxMFGROWTH*) suggests that, in times of increased property prices, deteriorating financial conditions lead to a decrease in the prepayment propensity of both types of borrowers. This suggests that if property market fundamentals are favorable, in terms of prices, borrowers are less likely to prepay and hold onto their assets. Or in other words, improving asset values moderate the prepayment propensity.

While a positive relationship of interest rate (*INTRATE*) and prepayment hazard is expected for floating rate borrowers, whose mortgage rates vary with interest rates in the market, the significantly positive, albeit only at the 10% level, relationship of *INTRATE* on prepayment propensity for fixed rate mortgages in Column 2 is surprising. However, in times of increased interest rates and deteriorating financial conditions (*MACROFxINTGROWTH*), the prepayment propensity of fixed rate borrowers decreases, which is in line with expectations.

The main effect of overall investor sentiment (*RERC*) has no effect on the prepayment propensity of fixed rate and floating rate loans. However, for both types of mortgages, the interaction effect of sentiment and real estate price growth (*MFGROWTHxRERC*) has a significantly positive effect on the prepayment hazard. This result suggests that in quarters in which real estate prices have increased, a higher investor sentiment (optimism) predicts more prepayments by fixed and floating rate borrowers.

If we focus on the irrational component of sentiment, i.e. the component of Situs RERC sentiment that is not explained by fundamentals, the main effect (*SENT.IRR*) has no impact on the prepayment propensity of fixed rate and floating rate mortgages. However, in times of increased property prices, irrational investor sentiment positively predicts prepayment propensity. In particular, in these periods, a higher irrational investor sentiment (*MFGROWTHxSENT.IRR*) predicts a higher prepayment hazard for fixed and floating rate mortgages. The effect of irrational investor sentiment on prepayment hazard is noticeably higher for floating rate mortgages than fixed rate mortgages. Our results for these interaction effects also suggest that the findings for *RERC* in times of increased property prices (*MFGROWTHxRERC*) may be driven by irrational investor sentiment to some degree.

Overall, our results in Table 4 suggest that the irrational sentiment in the multifamily market has predictive power for the prepayment of floating and fixed rate mortgages. They also suggest that the relationship of property prices and prepayment hazard identified in previous studies (Dierker, Quan and Torous, 2015; Huang and Ondrich, 2002) may be driven by irrational investor sentiment to some extent as opposed to merely fundamentals. In particular, irrational investor sentiment allows to predict mortgage prepayments in times of increased property values. This asymmetric relationship of investor sentiment and mortgage prepayment hazard is in line with previous studies that find the impact of investor sentiment on, for example, market liquidity or ex-ante risk premia of investors to vary across different regimes (e.g. Beracha, Freybote and Lin, 2019; Freybote and Seagraves, 2018).

[Insert Table 4 here]

To assess the robustness of our findings for the relationship of investor sentiment and prepayment hazard, we derive two alternative sentiment measures using generalized auto regressive conditionally heteroskedastic (GARCH) modeling technique. The advantage of this econometric technique is that we can estimate the volatility in a variable conditional on the most recent information available. The resulting GARCH-based sentiment measures are *GARCH.RERC* for the overall SITUS RERC measure and *GARCH.IRR* for the irrational component of investor sentiment. These measures reflect a perceived uncertainty in sentiments. Our results for *GARCH.RERC and GARCH.IRR* are presented in Table 5. The main effects of *GARCH.RERC* and *GARCH.IRR* have a significantly positive effect on the prepayment propensity of floating rate borrowers, but not fixed rate borrowers. This implies that the anxiety of floating rate borrowers who are more exposed to interest rate risk is further aggravated when they are relatively unsure about their sentiments which results in increased prepayment behavior. Thus, irrespective of property market conditions, overall and irrational investor sentiment predict the prepayment propensity of floating rate borrowers.

Furthermore, except *GARCH.IRR* in the case of floating rate mortgages, the interaction effect of the respective sentiment measure and *MFGROWTH* (*MFGROWTH x GARCH.RERC* and *MFGROWTH x GARCH.IRR*) is significantly positive for all borrower types. Thus, in times of increased property prices, investors in the multifamily market become more optimistic, borrowers appear to take advantage of the favorable market conditions and repay their mortgages as a result of refinancing or asset disposition. Overall, our results for the GARCH-based sentiment measures in Table 5 are in line with our findings in Table 4 that investor sentiment has predictive value for mortgage prepayments.

[Insert Table 5 here]

6. Conclusion

Previous studies have identified interest rates, property market fundamentals and call protection provisions to be important predictors of prepayments by commercial mortgage borrowers (e.g. Ambrose and Sanders, 2003; Fu, LaCour-Little and Vandell, 2003; Huang and Ondrich, 2002). We focus on the impact of investor sentiment on prepayment rates of multifamily CMBS loans to answer the question of whether investor sentiment has informative value for mortgage prepayments. We find that investor sentiment indeed predicts prepayment rates. In particular, we find that, in times of increased property prices, a higher irrational investor sentiment positively predicts prepayment propensity for fixed and floating rate mortgages. As irrational investor optimism drives up real estate prices and lowers cap rates, borrowers are more likely to refinance and take out equity or sell their building and thus prepay their outstanding mortgage balances before maturity. Our findings that irrational investor sentiment has informative value for the prepayment of mortgages is robust to different sentiment measures.

Our study provides evidence for the predictive power of irrational investor sentiment, in addition to property market conditions and interest rates, for the exercise of the prepayment (call) option by commercial mortgage borrowers. In other words, borrowers not only exercise their call option to prepay the outstanding loan balance before maturity if interest rates are sufficiently low and/or building values are sufficient high (Dierker, Quan and Torous, 2005; Kau et al., 1990), but also based on investor irrationality. Our results have implications for lenders and CMBS investors that may use investor sentiment measures such as the Situs RERC measure as an additional source of information to predict prepayments by commercial real estate borrowers.

We also consider our study a starting point for future investigations. Future studies may revisit our findings for other property types or investigate borrower behavior for different types of commercial real estate mortgages in more detail. These studies could, analogously to the housing market (Chen and Stafford, 2019; Philipps, Rosenblatt and Vanderhoff, 1996), investigate differences between floating-rate and fixed rate borrowers and their behavior in commercial real estate markets. Future studies with the appropriate datasets may furthermore use our findings as a starting point to investigate the impact of irrational commercial real estate investor sentiment on the behavior of commercial mortgage borrowers in different interest rate environments in more detail. These studies may, for example, investigate whether borrowers switch between fixed and floating rate mortgages in different interest rate, property market and sentiment environments.

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Table 1: Multifamily Loans Originations, Prepayment and Sentiment (2001 to 2015)

Year	Situs RERC Sentiment	Originations				Prepayments			
	Avg.	All	ReFi	Fixed	Floating	All	ReFi	Fixed	Floating
2001	6.9	6	0	6	0	0	0	0	0
2002	6.05	0	0	0	0	0	0	0	0
2003	4.8	0	0	0	0	0	0	0	0
2004	5.75	0	0	0	0	0	0	0	0
2005	5.9	45	3	45	0	1	0	1	0
2006	6.5	65	0	38	27	10	0	0	10
2007	5.9	194	0	100	94	29	0	16	13
2008	5.95	337	47	164	173	11	0	7	4
2009	5.63	111	26	107	4	21	1	21	0
2010	6.83	467	1	465	2	97	0	97	0
2011	7.33	1,368	9	1,281	87	355	3	277	78
2012	7.2	1,614	294	1,439	175	243	1	97	146
2013	6.85	1,344	262	1,013	331	210	0	52	158
2014	6.45	1,893	689	1,343	550	65	0	8	57
2015	5.9	3,284	1,640	1,799	1,485	1	0	1	0

Data Source: Bloomberg. This table summarizes the annual number of (government sponsored) agency multifamily CMBS loans based on their originations or prepayments across various types: refinancing loans, fixed-rate loans and floating-rate loans. Situs RERC sentiment represents the average annual sentiment measure based on the quarterly Situs RERC survey of apartment investors. The rating of investment conditions in this market ranges from 1 (poor) to 10 (excellent).

Table 2: Descriptive Variables for Loan and Deal Characteristics

Variable	Description	FULL SAMPLE				FIXED RATE	FLOATING RATE
Sample Size		10,728				7,800	2,928
		Min	Max	StD	Mean	Mean	Mean
Loan Characteristics							
PREPAID	Dummy for prepayment	0	1	0.30	0.10	0.07	0.16
REFI	Dummy for Refinancing	0	1	0.45	0.28	0.23	0.40
ACQUISITION	Dummy for acquisition financing	0	1	0.38	0.18	0.10	0.38
FIXED RATE	Dummy for Fixed interest rate	0	1	0.45	0.73	1	0
FLOATING	Dummy for floating interest rate	0	1	0.45	0.27	0	1
BAL($mi)	Original loan balance	0	878	20	11	10	16
LTV.L	LTV ratio of the loan	0.02	0.98	0.14	0.66	0.64	0.70
DSCR.L	Debt Service Coverage ratio of the loan	0	56.4	1.79	1.88	1.92	1.80
Loan Amortization Type							
BALLOON	Balloon loan	0	1	0.50	0.56	0.63	0.39
FULLY AMORT	Fully amortizing loan	0	1	0.12	0.01	0.01	0.02
IO	Interest only loan	0	1	0.27	0.08	0.09	0.05
PARTIAL IO	Partial interest only loan	0	1	0.48	0.35	0.27	0.54
PROTECT	Number of call protection provisions	0	3	0.59	1.14	1.16	1.08
Corresponding CMBS Deal							
DUS	Dummy for DUS loan type	0	1	0.20	0.04	0.05	0
D_ORGFACE	Original deal face value ($mi)	3	1,900	528	745	661	968
D_TRANCHES	Number of tranches in the deal	1	26	3.53	7.36	8.12	5.33
D_MATRANGE	Range (in days) of loan maturity across the underlying loans	0	9,527	1,780	1,585	1,504	1,797
D_SZRANGE	Range of loan size ($mi) across the underlying loans	0	298	46	61	56	74

Notes: This table summarizes our sample of multifamily loans issued and securitized by various US agencies between 2001 and 2015. All loan data is extracted from Bloomberg.

Table 3: Descriptive Statistics for Sentiment and Fundamental Variables

Variable	Description	Data Source	Min	Max	StD	Mean
INTRATE	Average interest rate on multifamily mortgage loans	NCREIF	3.81	7.05	0.91	5.31
CPPI	Multifamily Property Price Index	Moody's	-3.66	1.74	1.15	0.41
TERM	Yield Spread between 10-Year Treasury Bond and the risk-free rate	Federal Reserve	-0.43	3.61	1.09	2.09
DEFAULT	Yield Spread between Moody's BAA bonds and the risk-free rate	Moody's	1.18	8.54	1.62	4.82
LTV.M	Average loan-to-value ratio on outstanding multifamily loans	NCREIF	0.44	0.74	0.07	0.53
SNP500	Return on S&P 500 Index	CRSP	-7.88	4.91	2.84	0.34
VIXSP500	S&P 500 Implied Volatility Index	CBOE	11.02	58.86	8.49	20.50
CRTIGHT	Survey based net % measure of tightening in commercial loans	Senior Officer Loan Survey	-24.1	83.6	26.2	5.7
MACROF	Principal component of the macroeconomic factors (above)	estimated	-2.67	6.60	1.86	0.00
RERC	Multifamily Investor Sentiment Index	Situs RERC	3.90	7.50	0.75	6.26
SENT.IRR	The residual component of RERC unexplained by macroeconomic factors	estimated	-2.13	1.55	0.62	0.00

Note: This table presents the descriptive statistics for sentiment, macro-economic, capital and property market variables over the period of Q1/2001 to Q4/2015.

Table 4: Cox Proportional Prepayment Hazard Models with Sentiment

	Fixed Rate		Floating Rate	
	(1)	(2)	(3)	(4)
Loan Characteristics				
ACQUISITION	-1.199	-1.193	**1.788*****	**1.810*****
REFINANCE	0.484	0.456	**2.046*****	**2.047*****
Ln(BAL)	0.008	0.010	-0.063	-0.086
FULLY AMORT	-0.096	-1.190	-0.798	-0.794
IO	-0.051	-0.057	**-0.666****	**-0.667****
PARTIAL IO	**-0.573*****	**-0.564*****	**0.259***	**0.253***
LTV.L	-0.447	-0.488	**3.021*****	**3.035*****
DSCR.L	-0.019	-0.019	**0.678*****	**0.753*****
Fundamentals and Sentiment				
INTRATE	0.668	**0.878***	**5.444*****	**5.683*****
MACROF	**1.376****	**1.550*****	**2.164****	**2.431****
MFGROWTH	**-7.671*****	**-2.028*****	**-9.218*****	**-3.080****
INTGROWTH	**3.411****	**-3.073*****	-1.377	-0.894
RERC	0.329		0.022	
SENT.IRR		0.191		-0.081
MACROF x MFGROWTH	-1.160	**-1.713*****	**-3.167****	**-3.668*****
MACROF x INTGROWTH	**-3.205*****	**-2.699*****	0.667	0.053
MFGROWTH x RERC	**0.958****		**0.998****	
MFGROWTH x SENT.IRR		**0.681***		**1.279*****
Originator dummies	*Yes*	*Yes*	*Yes*	*Yes*
State dummies	*Yes*	*Yes*	*Yes*	*Yes*
Deal Characteristics	*Yes*	*Yes*	*Yes*	*Yes*
N	0.294	0.294	0.437	0.438
R^2	0.681	0.681	0.874	0.874
Max. Possible R^2	-3,099.207	-3,100.848	-2,187.372	-2,183.423
Log Likelihood	165.440**	50.850	448.270***	443.540***
Wald Test	2,715.403***	2,712.120***	1,679.792***	1,687.690***
LR Test	5,078.424***	5,042.239***	1,882.864***	1,882.387***
Score (Logrank) Test	0.294	0.294	0.437	0.438

Notes: This table reports the result of Cox proportional hazards regression model for loan prepayment in Multifamily CMBS loans originated and securitized by government sponsor agencies between 2001 and 2015. Variable Definitions are in Table 2 and 3. MFGROWTH is a binary variable indicating that the CPPI grew compared to the previous quarter, INTGROWTH is a binary variable indicating that INTRATE grew compared to the previous quarter. All models control for originators, deal characteristics, call protection provisions and location (state).

****, ** and * signify statistical significance at 1%, 5% and 10% respectively.*

Table 5: Cox Proportional Prepayment Hazard Models with GARCH-Based Sentiment

	Fixed Rate		Floating Rates	
	(1)	(2)	(3)	(4)
Loan Characteristics				
ACQUISITION	-1.244	-1.118	**1.759*****	**1.741*****
REFINANCE	0.233	0.186	**1.977*****	**1.997*****
Ln(BAL)	0.018	0.017	-0.046	-0.058
FULLY AMORT	-2.547	-1.226	-0.560	-0.556
IO	-0.086	-0.067	**-0.634****	**-0.617***
PARTIAL IO	**-0.563****	**-0.580****	0.201	0.200
LTV.L	-0.446	-0.566	**3.260*****	**3.295*****
DSCR.L	-0.009	-0.017	**0.621*****	**0.594*****
Fundamentals and Sentiment				
INTRATE	**1.701****	**2.340*****	0.250	**6.315*****
MACROF	**1.842****	**2.349*****	1.642	**3.484*****
MFGROWTH	**-7.578*****	**-4.958*****	**-7.479*****	**-6.144*****
INTGROWTH	**-3.105*****	**-3.536*****	**-1.600***	**-1.731***
GARCH.RERC	-1.068		**5.339****	
GARCH.IRR		-2.222		**4.790***
MACROF X MFGROWTH	**-3.225*****	**-2.774*****	**-4.994*****	**-6.437*****
MACROF X INTGROWTH	**-2.844*****	**-3.260*****	-1.060	-0.483
MFGROWTH X GARCH.RERC	**7.846*****		**4.915*****	
MFGROWTH X GARCH.IRR		**3.387***		-0.856
Originator dummies	*Yes*	*Yes*	*Yes*	*Yes*
State dummies	*Yes*	*Yes*	*Yes*	*Yes*
Deal Characteristics	*Yes*	*Yes*	*Yes*	*Yes*
N	*7,800*	*7,800*	*2,928*	*2,928*
R^2	*0.295*	*0.292*	*0.437*	*0.438*
Max. Possible R^2	*0.681*	*0.681*	*0.874*	*0.874*
Log Likelihood	*-3,094.720*	*-3,108.021*	*-2,186.075*	*-2,183.965*
Wald Test	*348.310****	*168.980****	*459.950****	*457.230****
LR Test	*2,724.376****	*2,697.775****	*1,682.387****	*1,686.606****
Score (Logrank) Test	*5,000.736****	*4,899.320****	*1,902.833****	*1,893.463****

Notes: This table reports the result of Cox proportional hazards regression model for loan prepayment in Multifamily CMBS loans originated and securitized by government sponsor agencies between 2001 and 2015. GARCH.RERC and GARCH.IRR are GARCH-based measures of the SITUS RERC (RERC) and irrational sentiment (SENT.IRR) respectively. Variable definitions are in Table 2 and 3. MFGROWTH is a binary variable indicating that the CPPI grew compared to the previous quarter, INTGROWTH is a binary variable indicating that INTRATE grew compared to the previous quarter. All models control for originators, deal characteristics, call protection provisions and location (state).

****, ** and * signify statistical significance at 1%, 5% and 10% respectively.*

Figure 1: Number of Agency and DUS Multifamily CMBS Deals (2001 to 2015)

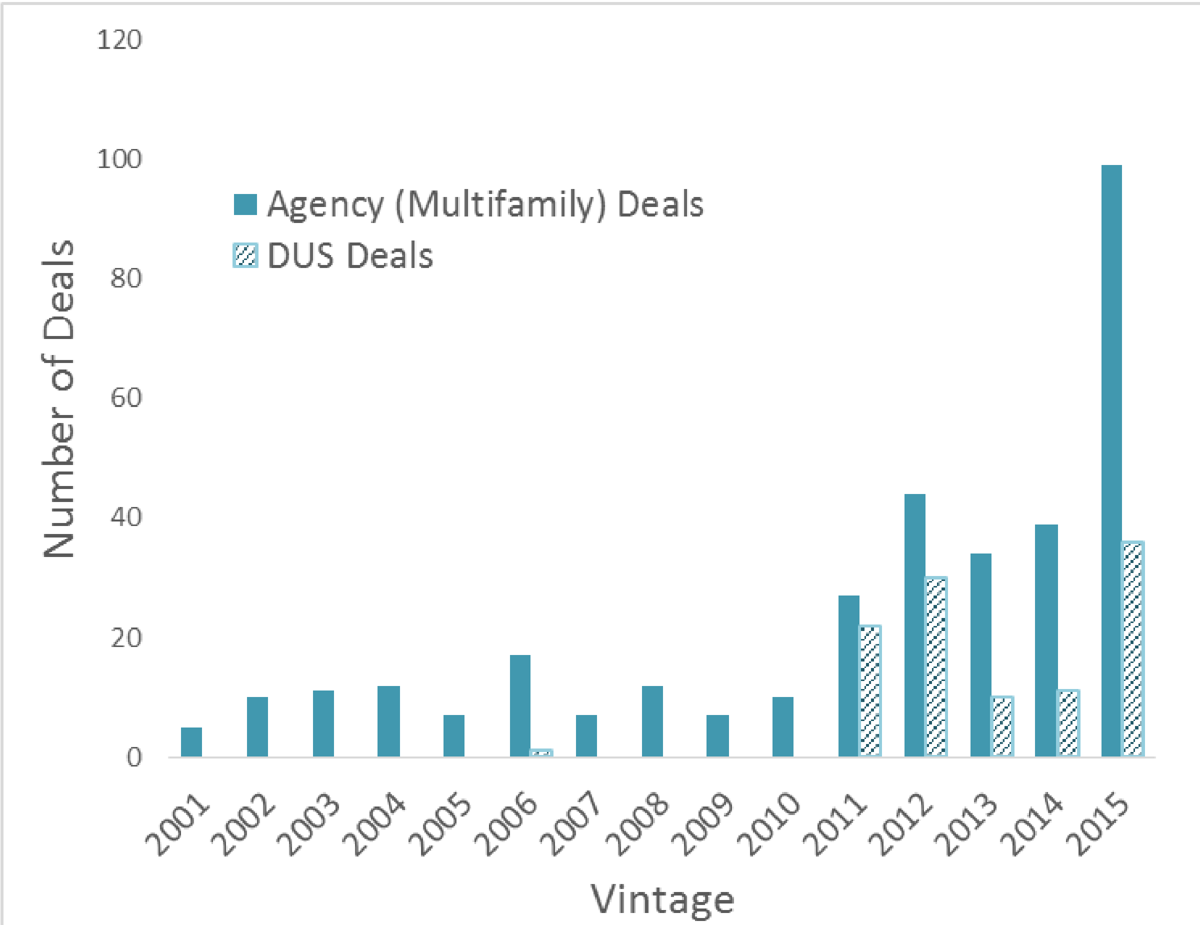
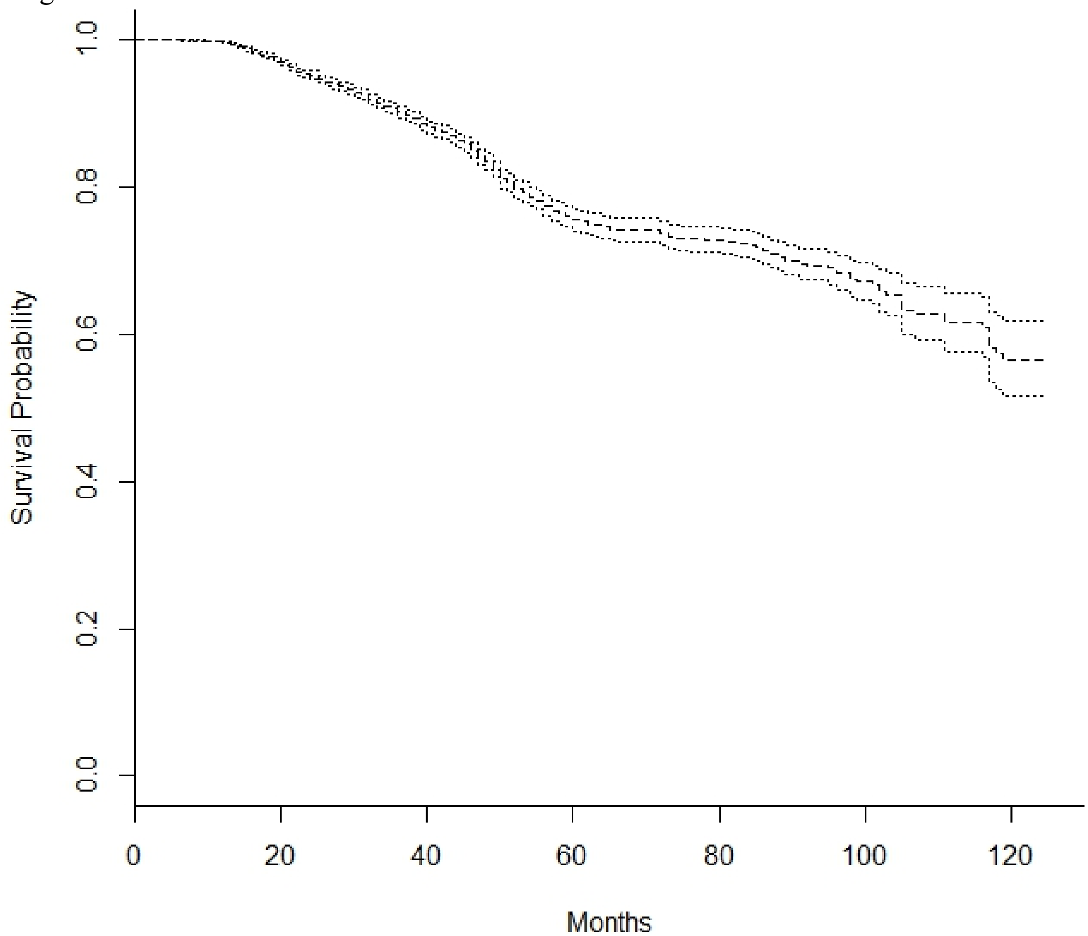


Figure 2: Kaplan-Meier Non-Parametric Survival Rate in Agency Multifamily CMBS Loans Originated Between 2001 and 2015



Note: The thin dotted lines depict the confidence intervals (95%) of the survival rate curve.

Figure 3: Kaplan-Meier Non-Parametric Survival Rate in Agency Multifamily CMBS Loans Originated Between 2001 and 2015 Across Mortgage Types

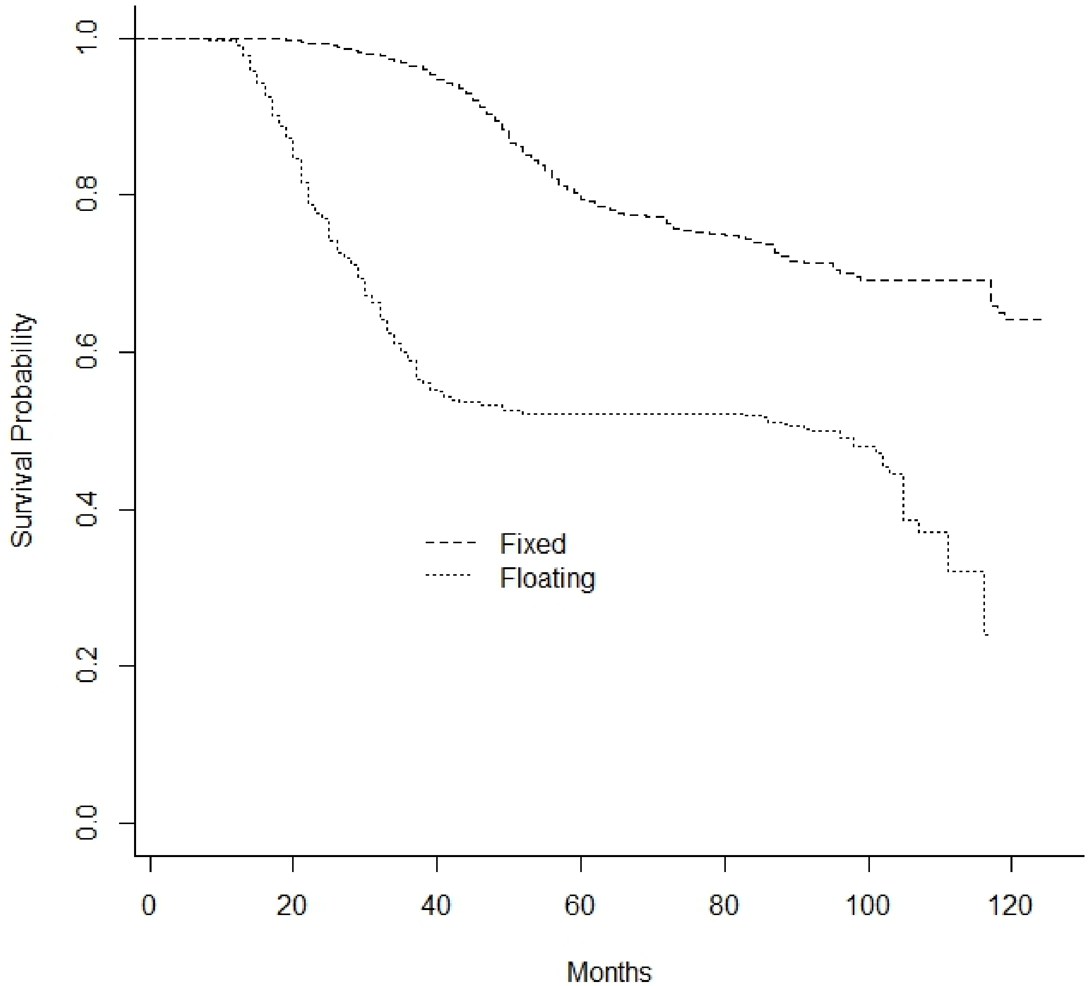


Figure 4: Kaplan-Meier Non-Parametric Survival Rate in Agency Multifamily CMBS Loans Originated Between 2001 and 2015 Across Agency Deal Types

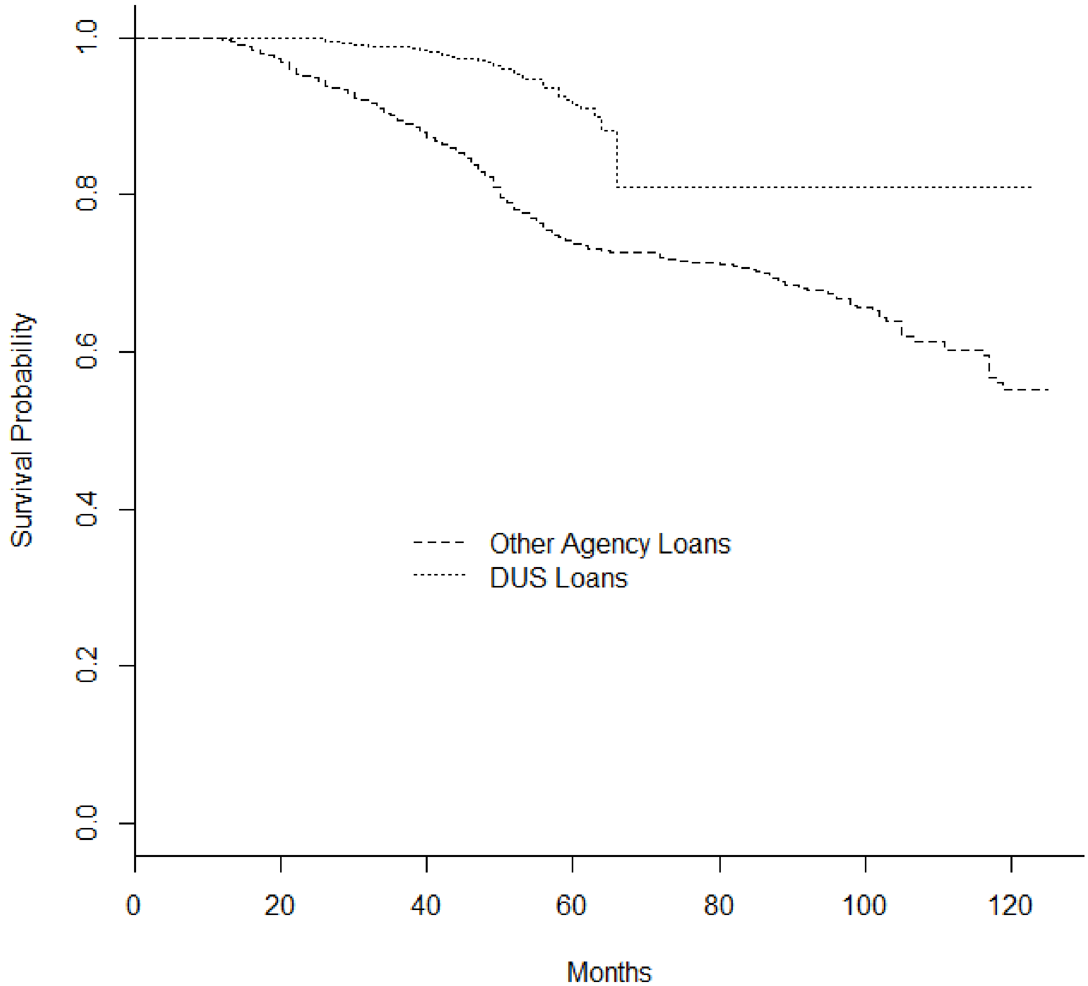


Figure 5: Kaplan-Meier Non-Parametric Survival Rate in Agency Multifamily CMBS Loans Originated Between 2001 and 2015 for New Purchase and Refinance Mortgages