Subordination Levels in Commercial Mortgage-backed Securities (CMBS)*

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Executive Summary

Subordination levels are of critical importance in the classic senior-subordinated structure for securitized financing such as collateralized debt obligations (CDO) and commercial mortgage-backed securities (CMBS). Subordination levels determine the amount of credit support that the senior bonds (or tranches) require from the subordinated bonds (or tranches) and are provided by the rating agencies. For a specific CMBS deal, investors for senior bonds prefer to have higher level of subordination to shield themselves from the default loss. On the other hand, security issuer's preference requires the least subordination to achieve certain credit ratings of their bonds. Therefore, understanding subordination design is of great interest to various parties including investors, issurers, and financial economists. Recent studies document rating agencies' "learning by doing" in subordination design (Sanders 1999, Riddiough 2004), and that CMBS subordination levels might have been over-set historically (Downing and Wallace 2005).

In this paper, we focus on the cross sectional differences in subordination levels among different CMBS deals. We ask two empirical questions: 1) what determines subordination levels? 2) whether CMBS bonds (or tranches) with greater levels of subordination do, in fact, experience higher levels of delinquencies and default.

We perform both a deal level and a loan level analysis using data on US CMBS securities issued during 1995 and 2005. We first regress AAA (low-risk) and BBB (higher-risk) CMBS bond subordination levels to both credit and non-credit related variables at deal level to investigate the determinants of subordination levels. Second, we examine default behavior of commercial mortgage loans underlying CMBS deals by estimating a hazard model, and use the model to simulate the expected loss of those loans. Finally, we calculate the expected loss for CMBS pools based on expected losses of underlying loans and test whether the relationship between subordination and ex-post delinquencies and defaults is conforming to rational expectation.

Our results show that debt service coverage ratio (DSCR), and measures of deal property type composition and prepayment protection are important in subordination design. We also find cutoff year to be significant and verify the trend of contraction of subordination levels over time. Expected loss for CMBS pools is a statistically significant factor in explaining both AAA and BBB bond subordination levels; however, it accounts for less than 35 percent of the variation. This result suggests that it is difficult to establish a deterministic relation between subordination levels and default loss, a priori, and that investors need to pay close attention in discerning different deals.

Subordinations Levels in Commercial Mortgage-backed Securities (CMBS)

1. Introduction

The structured financing such as collateralized debt obligations (CDOs) and commercial mortgage-backed securities (CMBS) has grown rapidly during the past two decades[1]. An attractive feature of CMBS to investors is the senior-subordinated debt structure where cash flows from underlying commercial mortgage pool are allocated to various tranches of securities (bonds) according to predetermined rules. Typically, repayments of principal are distributed first to the senior tranches while losses due to default are allocated first to the subordinated tranches. Therefore, investors buying senior tranches expect to be well protected from credit risks while those holding subordinated tranches will expect higher premium.

In essence, bond subordination levels are the keys to determine how much credit support senior tranches have from the subordinated tranches. For each CMBS deals, the issuer can improve market value of the deal with the least amount of subordination in order to carve as many senior bonds as possible from the deal. But at the same time, he needs to convince the investors that the subordination is enough to keep them away from certain levels of credit risk. In this regard, rating agencies design subordination for each deal and provide a credit risk assessment – bond ratings. Therefore, rating agencies play important roles in subordination design. A stylized fact about CMBS subordination levels

[1] For example, CMBS annual issuance in US has grown from less than $1 billion in 1985 to $169 billion in 2005. CMBS outstanding at the end of 2005 reached $550 billion, which accounts for about 21 percent of $2.6 trillion commercial mortgage outstanding.

is that there exists a time series trend showing subordination levels declining systematically over time. This decline in subordination levels has been attributed to the paucity of information about delinquencies, defaults and foreclosures on loans in assisting subordination design, and rating agencies' "learning by doing" (Sanders 1999, Riddiough 2004). Recent research by Downing and Wallace (2005) regarding CMBS suggests that, even for recently issued CMBS bonds, the observed subordination levels are higher than the optimal level, and that the market should see further reductions in subordination.

A parallel question to how CMBS subordination design evolves over time is what determines cross sectional differentials in subordination levels among different CMBS deals. This is an interesting question because of several reasons: first, rating agencies develop their own internal models for subordination design. Therefore, little is known to the public (including investors and financial economists) about how different credit risk and non-credit risk factors affect subordination. Second, CMBS investors want to differentiate "good" deals from "bad" deals. Therefore, testing whether CMBS bonds (or tranches) with greater levels of subordination are expecting higher ex-post levels of delinquencies and default is very important to them. Third, even if the rating agencies can use a static or a dynamic approach to provide unbiased prediction of the credit risks down the road, investors will still be interested in learning the preciseness (confidence interval) of the prediction.

Our research questions are: 1) what determines subordination levels? 2) whether CMBS bonds (or tranches) with greater levels of subordination do, in fact, experience higher ex-post levels of delinquencies and default.

We perform both a deal level and loan level analysis. First, we examine how AAA and BBB bond subordination levels can be explained by both credit and non-credit related variables at deal level. We pay special attention to the roles of original LTV and original DSCR. While the two variables are commonly viewed as the most important default risk measures, several recent studies suggest they may not be good credit risk predictors because they are endogenous to commercial mortgage credit risk (Archer et al 2001, Ambrose and Sanders 2003, Ciochetti et al 2003, Deng, Quigley and Sanders 2005). Second, we directly link AAA and BBB subordination levels with CMBS pool credit risks. The latter are measured as aggregate expected losses of commercial mortgage loans underlying each pool. Commercial mortgage loan expected loss is calculated by using the estimated commercial mortgage default probabilities and a set of predetermined loss severity rates by various property types.

Our analysis is based on a unique dataset which contains both CMBS deal level information and underlying commercial mortgage loan information. This dataset includes deal subordination levels and loan specific data such as loan-to-value (LTV) ratio, debt service coverage (DSCR) ratio, location of property, and loan outcomes in terms of prepayment, delinquency and default. Our dataset contains 350 CMBS conduit deals and approximately 30,000 commercial mortgage loans underlying those deals.

Our results show: 1) CMBS deal cutoff DSCR, property type and prepayment constraints offer significant explanatory power in determining CMBS bond subordination. Together, they explain about 90 percent of cross sectional variations in AAA subordination levels and about 80 percent of variations in BBB subordination levels; 2) cutoff year also provides some explanatory power for the CMBS subordination levels. In

other words, there is a trend that subordination levels for both AAA and BBB tranches are declining over time; 3) the expected loss at CMBS pool level is a statistically significant factor in explaining both AAA and BBB bond subordinations; however, they only account for less than 35 percent of the variation. This result suggests that it is difficult to establish a deterministic relation between subordination levels and default loss, a priori, and that investors need to pay close attention in discerning different deals.

Part of our analysis of CMBS subordination is based on the hazard model for commercial mortgage default which is well developed in the mortgage default risk literature (e.g. Deng, Quigley and Van Order 2000). The model provides useful information on loan level default risk analysis for both the academic and industrial practitioners such as rating agencies, commercial mortgage lenders and CMBS investors.

The section 2 briefly summarizes the mechanism of CMBS structure and subordination; section 3 explains our research questions and empirical approach; sections 4 and 5 describe the data and model results; concluding remarks are in a final section.

2. CMBS Product Design and Subordination

2.1 CMBS structure

Commercial mortgage-backed securities are an example of a structured finance product where assets are pooled and tranched. Commercial mortgages are pooled together by CMBS issuers and several tranches of securities are created and sold to investors. A number of studies have shown that this pooling and tranching mechanism helps mitigate market imperfections and creates value (Riddiough 1997, DeMarzo and Duffie 1998, DeMarzo 2005 and Gaur, Seshadri and Subrahmanyam 2005). Intuitively, the pooling and tranching process enhances liquidity, diversification and risk management: by selling

relatively "standard" and low-risk CMBS bonds (cash flows) rather than heterogeneous loans, the process greatly enlarges the investor base and facilitates capital flow in commercial mortgage market; in many cases, a large number of loans are pooled together to create diversification effect; finally, several entities with special expertise, such as commercial mortgage underwriter, CMBS issuer, master servicer, special servicer and rating agency are involved in the process to help achieve better risk management.

A typical CMBS is formed when an issuer deposits commercial mortgage loans into a trust[2]. The issuer then pass information of those loans into rating agencies, and rating agencies create a series of tranches (bonds) backed by the loans, which form the senior-subordinated debt structure. The tranches have varying credit qualities from AAA, AA (senior tranche), to BB, B (subordinated) and to unrated (first loss)[3] given that any return of principal generated by amortization, prepayment and default is allocated to the highest-rated tranche first and then the lower-rated tranches, while any losses that arise from a loan default is charged against the principal balance of the lowest-rated tranche that is outstanding (first loss piece).[4] Any interest received from outstanding principal is paid to all tranches[5]

Credit risk is the major concern of CMBS mainly because of two reasons: 1) commercial mortgages underlying CMBS deals are mostly restricted or deterred from prepayment by lockout, yield maintenance, defeasance and/or prepayment penalties; 2) commercial mortgages have substantially higher default rates than residential mortgages.

[2] The loans could be bought from traditional lenders, portfolio holders or from conduit loan originators.
[3] Many CMBS deals also have an interest only (IO) tranche which absorbs excess interest payment.
[4] This type of structure is often referred to as the "reverse waterfall" structure.
[5] It is noteworthy that many CMBS deals vary from this simple structure. For more information, see Sanders (1999). Also see Sanders (1999) and Geltner and Miller (2001) for other issues such as commercial mortgage underwriting, form of the trust, servicing, commercial loan evaluation, etc.

Investors in subordinated tranches can get a as high as 500 bps spread over comparable maturity treasuries (depending on market conditions), while those who invest in AAA tranches get much lower spread since they are expected to be protected by the subordinated tranches of credit risk.

2.2 Subordination

For each CMBS tranche, subordination level is defined as the proportion of principal outstanding of other tranches with lower rating. It reflects "credit support" of that tranche. Rating agencies determine subordination levels at deal cutoff. Typically, the CMBS issuer assembles a pool of loans and passes the information of these loans to rating agencies. Rating agencies then work independently to examine how much subordination is needed for the tranches to reach certain ratings, such as AAA, AA, A, BBB etc. This forms the perspective debt structure. In most cases, this debt structure is the final deal structure accepted by the issuer and provided to the investors. However, in case the issuer does not like the deal structure designed by the rating agencies, he (she) may choose to remove certain loans from the pool and ask the rating agencies to re-design the structure. Usually two or more rating agencies are invited to CMBS rating and the proposing-revision process for subordination goes recursively[6]. Once the deal structure is finalized, rating agencies provide their credit risk assessment – bond ratings for each CMBS tranche. CMBS investors rely on the quality certification given by rating agencies and tell credit quality differences between different tranches mainly by their ratings[7].

[6] Moody's, Standard and Poor's and Fitch are currently three major CMBS rating agencies.
[7] Rating agencies also monitor each CMBS bond after its issuance, and like in corporate bond market, they upgrade and downgrade some bonds according to the change in the CMBS pool performance.

In assessing subordination, rating agencies gather CMBS deal and underlying loan information and use models to estimate subordination levels needed for each CMBS deal. In fact, each rating agency has its own internal model. However, the general framework is approximately the same. Rating agencies perform typically three levels of analysis[8]: 1) on the property level, based on commercial mortgage loan underwriters' cash flow report, rating agencies adjust property net operating income (NOI) based on their own judgments of whether the number in underwriting report is sustainable given the current market condition and deduct capital items such as capital reserves, tenant improvement and leasing commissions to form the so called net-cash flow (NCF). Rating agencies then calculate property value using their own capitalization rates, which could be different from the current market capitalization rate[9]. Rating agencies may also calculate their "stressed" LTV and DSCR for each loan and feed their stressed LTVs and DSCRs into a loss matrix to form the basic credit support assessments. 2) On the loan level, rating agencies look at borrower quality, amortization, cash management, cross- and over-collateralization to make adjustment to their basic credit support assessments. After doing this, rating agencies aggregate their analysis into the pool level and assign subordination to each proposed CMBS tranches[10]. 3) Finally rating agencies perform portfolio level analysis, which examines pool diversity, information quality and legal and structural issues, and makes final adjustment to subordination levels for each CMBS bond.

[8] We are indebted to Sally Gordon from the Moody's for offering valuable information regarding the rating and subordination design process.
[9] For example, Moody's uses a stabilized cap rate to try to achieve a "through-the-cycle" property value.
[10] Although rating agencies perform property and loan analysis mainly on individual basis, they sometimes only review a random sample (40-60%) of the loans when number of mortgages in the pool is large, the pool was originated with uniform underwriting standards and the distribution of the loan balance is not widely skewed.

It is noteworthy that there is no standard for subordination design, and the models used by rating agencies are evolving over time. Recently, some rating agencies have started to employ a dynamic approach to assist the static approach in subordination design. Rather than relying on the static stressed LTV and DSCR and other information at deal cutoff, the dynamic approach attempts to incorporate a default probability model and loss severity model to predict commercial mortgage and CMBS pool expected loss over a relatively long horizon[11]. This is potentially a more desirable approach because the optimal subordination is essentially the expected life time loss of the deal. However, the dynamic approach is still playing a complementary role in the industry and the static approach is the dominating methodology used in subordination design.

3. Research Questions and Empirical Approach

There has been growing amount of interest in the economics of subordination in CMBS in recent years. For example, Riddiough (2004) studies how CMBS subordination and credit spread evolve over time. The study suggests that rating agencies follow a "learning by doing" approach in subordination design. This explains the stylized fact that subordination levels have declined systematically since 1997 (Sanders 1999, Geltner and Miller 2001). Downing and Wallace (2005) study the optimal subordination design. From CMBS issuers' perspective, the least subordination for a given rating structure is desirable because the issuers can sell the senor tranches with a premium but the subordinated tranches with a discount. On the other hand, investors buying senior tranches always want as much subordination as possible to protect them from the pool default risk. Therefore the optimal subordination design requires a fair coverage of

[11] For example, Moody's uses its Commercial Mortgage Metrics (CMM) to assist subordination design nowadays.

CMBS credit risk. They use a structural commercial mortgage-pricing model to infer the optimal CMBS bond subordination levels. They find subordination levels observed in the market are higher than their estimates and conclude that the market will likely see further reductions in subordination.

In addition to the time series perspective of subordination design, the cross sectional property of subordination levels is an important research topic. First, limited empirical work has been done to examine determinants of subordination. Each rating agency uses its internal model for subordination design. Therefore, little is known to the public (including CMBS issuers, investors and financial economists) about how different credit risk and non-credit risk factors affect subordination. Second, CMBS investors want to differentiate less risky deals from more risky deals. Although existing research has found that overall subordination has been more than enough to protect senior tranches from credit risk, it is not clear whether investors buying different CMBS bonds with the same rating are equally compensated for the risks taken. Therefore, testing whether CMBS bonds (or tranches) with greater levels of subordination experience higher ex-post levels of delinquencies and default is very important. Third, we know CMBS issuers and rating agencies make assessments of deal credit risk based on deal cutoff information. Several researches suggested that using deal cutoff information only may not produce good estimates of deal credit risk. For example, increasing volume of studies has shown that it is the contemporaneous loan-to-value ratio (LTV) and debt-service-coverage ratio (DSCR) rather than LTV and DSCR at loan origination (original LTV and DSCR) that determines commercial mortgage default risk (Vandell et al 1993, Archer et al 2001, Ciochetti et al 2003, and Deng, Quigley and Sanders 2005). Even if the dynamic

approach is adopted to predict credit risk of each loan, it is a challenging task to make predictions of state variables such as interest rate and property value. With all these moving targets in mind, it will be useful to have a comprehensive understanding of the subordination design process.

Therefore, we focus on the cross sectional properties of subordination levels in this paper and ask the following questions:

1) what determines subordination levels?

2) whether CMBS bonds (or tranches) with greater levels of subordination do, in fact, experience higher ex-post levels of delinquencies and default.

To answer these questions, we propose empirical tests based on both a deal level analysis and a loan level analysis. In the deal level analysis, we examine how AAA and BBB bond subordination levels are related to deal level credit and non-credit variables. A linear regression model is estimated where the dependent variables are AAA and BBB bond subordination. We use variables observable at deal cutoff as our explanatory variables. These variables include credit risk factors, such as property types, loan size concentration and over-collateralization. We pay special attention to the roles of LTV and DSCR, because they are commonly viewed as the most important credit risk factors. We also include deal cutoff year dummies in the model. By estimating this model, we can infer what kind of factors explain the cross sectional variations in subordination.

In a loan level analysis, we directly link AAA and BBB subordination levels with the expected performance of CMBS deal underlying loans. Ideally, the subordination level should be associated with the expected deal loss over the lifetime of the bond, which is the aggregation of expected losses of underlying loans. Therefore, we should

anticipate expected deal losses to be a significant factor and to have substantial explanatory power of cross sectional variations in subordination. The empirical loan level analysis is specified using the following steps: first, we identify all commercial mortgage loans underlying the deals in the deal level regression; second, we estimate a hazard model for conditional default probabilities of commercial mortgage loans. We follow the literature to include the most important variables such as the intrinsic value of call exercise and the intrinsic value of put exercise (contemporaneous LTV) as our covariates. We also incorporate property types, regional dummies and market environments such as credit spread, volatility of risk free rate and unemployment rate. Unfortunately, we do not have a contemporaneous DSCR variable available. However, if we assume a stabilized cap rate as is commonly done by rating agencies, we know this variable is perfectly correlated with contemporaneous LTV. Third, we make predictions of default probabilities for each loan using the model we just estimated, excluding insignificant variables, if there is any. Next, we calculate expected losses of each loan over a specific time horizon based on default probability predictions and on assumptions of loss severities for each property type used as industry norm (expected loss = default probability × loss given default). We then aggregate expected losses of these loans into CMBS deals to calculate expected deal losses over certain horizons. Finally, we regress AAA and BBB subordination levels on expected deal losses to see how cross sectional variations of subordination can be explained by differences in deal credit risk. We should not expect a perfect correlation because there are other omitted factors such as legal and structural differences[12], information quality and borrower characteristics which affect

[12] As discussed previously, some deals may have special features on deal structure and legal arrangements. although they are all within the senior-subordinated framework.

pool credit risks but not included in our analysis. However, we should expect a high correlation given we have the most important variables included in our model.

4. Data

We use both deal level and loan level information in our analysis. At the deal level, we construct a dataset on CMBS deals based on information collected from CMBS.COM[13]. The raw database contains 718 CMBS deals and it covers virtually all CMBS deals made in US during the period of 1995 to early 2005. The data collection point is April 1, 2005. For each deal, we have detailed information on deal characteristics, such as cutoff date, balance, LTV, DSCR, AAA and BBB subordinations, property type composition, etc. Current (data collecting point) values of LTV, DSCR, balance, AAA and BBB subordinations are also recorded.

The 718 CMBS deals are of several types, including conduit deal, portfolio deal, franchise deal, single borrower deal, large loan deal, etc. We focus on conduit deals with all fixed rate loans underlying the pools only. Conduit deals are those deals with underlying commercial mortgage loans originated for the sole purpose of securitization[14]. Conduit deals usually have more uniform underwriting standards than other deals such as portfolio deals and single borrower deals. Our final sample contains 350 observations, which is 48.75% of the raw sample.

Table 1 shows the cut off year distribution of these 350 conduit deals. In 1995, there are only 2 deals in our sample, while in 2004, there are 62 deals. Table 1 also shows

[13] The company was sold to Standard & Poor's first and later to Backshop.
[14] In contrast, another important type of deals, portfolio deals, have underlying loans originally held in whole loan form by lenders or other investors and then sold to CMBS issuers.

the percentage of conduit deals as of all deals in each year. It shows increasing popularity of conduit deals over time.

Table 2 reports the descriptive statistics of the 350 deals. On average, there are 150 commercial mortgage loans underlying each deal. CMBS deals are huge, with an average cutoff balance of $1,110 million. AAA subordination levels range from 9% to 37%, and BBB subordination levels range from 2% to 17%. The average AAA subordination level is 21 percent. The weighted average LTVs at cutoff are between 43% and 77%, and the mean cut off debt-service-coverage ratio (DSCR) is 1.57. CMBS.com also report the estimated LTV at maturity of each deal, which is a proxy for balloon risk. The average estimated LTV and maturity is 57%. Usually a CMBS deal contains different property type loans. The property type composition is shown in table 2. Most CMBS loans have prepayment constraints, such as yield maintenance, lock out and defeasance. The coverage measures shown in table 2 are calculated as the weighted average mortgage term (in months) covered by lockout, yield maintenance and defeasance. Early originated commercial mortgage loans usually have lock out terms, which covers 28% of the sample months. Since 2003, defeasance has become a very popular form of prepayment constraint[15], which covers over 50 percent of our sample months.

Further, we match our CMBS deal database with a large commercial mortgage loan performance database from Intex to directly identify loans underlying some of the CMBS deals. The loan history dataset of commercial mortgages contains information about 50,000 loans. The dataset contains detailed information on origination date,

[15] In fact, some investors regard defeasance as a way to get around prepayment constraint, since it allows the borrower to refinance the loan as long as treasury securities are used to replace the loan.

original balance, original LTV and DSCR, mortgage rate, term, type and location of the property, paid off date, delinquency status, etc. Most importantly, it contains loan performance information (defaulted, prepaid, mature or current). The data reporting date is June 1, 2003. We loose 176 deals (in the 350 deal sample) due to matching problem and end up with 174 conduit deals associated with 28,124 loans. Table 3 lists the name and number of loans of all these deals. Number of loans underlying each deal varies from 28 to 421, with an average of 156. These deals are cutoff during 1995-2003 (Table 4).

Table 5 shows the origination year distribution of 28,124 loans left in our sample. Parallel to the year distribution of deals, we have fewer loans originated in 1994 and 1995. We will have more discussion of the characteristics of these loans when we get into the loan level analysis results.

We also use other data sources such as 1) interest rates from the Federal Reserve, 2) commercial property index from the National Association of Real Estate Investment Trusts (NAREIT) for the use of calculating option values[16], and 3) state level unemployment rates from the Bureau of Labor Statistics (BLS).

5. Results

5.1 Deal Level Subordination Analysis

Table 6 reports regression results of both AAA and BBB subordination levels. Since credit risk is the most important concern of CMBS investments, and rating agencies are reported to pay special attention to DSCR, we first run the simple models that include only DSCR and an intercept as explanatory variables (model 1)[17]. The results show that DSCR is indeed a very important variable in explaining subordination design. It is

[16] We acknowledge one shortcoming that the NAREIT index is for equity but not asset.
[17] We don't include the cutoff LTV in our model because it is highly correlated with DSCR.

negatively related to both AAA and BBB subordination levels, and variation in DSCR explains about 30 percent of variations in both AAA and BBB subordination levels.

In the more complete model, we add a number of variables. For example, we add estimated LTV at maturity as a measure of balloon risk; we add property composition variables; we also include prepayment constraint variables. Most of the relationships seen from the estimates are conforming to expectation, e.g. the higher the percentage of retail, anchored loans, the lower the subordination levels are (multifamily loan share is omitted as a reference group); while the higher the percentage of self-storage loans, the higher the subordination levels are. In addition, yield maintenance coverage is negatively related to subordination levels, because it mitigates prepayment risk. On the contrary, defeasance coverage is significant and positive possibly because borrowers choose to have defeasance terms at origination have higher potential refinance risk. There are some surprises: over-collateralization has no impact on AAA subordination levels but positive impact on BBB subordination levels, although we know it reduced commercial mortgage credit risk. Share of office loans is negatively related to subordination levels, which contradicts with common wisdom that office loans are riskier than multifamily loans. The share of top 5 loans is negatively related with subordination levels, which is contrary to the notion that diversification helps reduce credit risk. The BBB subordination model generally has the same results.

The overall fitting of the models is quite strong. The simple linear regression models explain nearly 90 percent of variations in AAA subordination levels and over 80 percent of variations in BBB subordination levels.

Table 7 reports additional analysis of subordination with time trend. In the first set of models, including a simple time trend as an explanatory variable suggests that subordination levels contract 1.5 percent every year. In the second set of models, we use year dummies rather than a simple time trend. The results are consistent with the simple time trend model – we see a monotonically decreasing subordination levels reflected in the dummy variable coefficients. Other results do not change in the time trend model comparing to the base model in table 3.

5.2 Default Risk Analysis

As discussed in the data section, we identify 28,124 commercial mortgage loans underlying 174 CMBS deals. Our loan level analysis is based on these 28,124 loans originated during 1994-2003. The loans are widely distributed among 10 regions (see Table 8), with the highest share of Southern/Atlantic. Southern/West Coast, Western/Southern Pacific and Northeast/Mid-Atlantic also have over 10 percent loans populated. A further analysis show that these loans are originated in 51 US states plus two US territories, Puerto Rico and Virgin Islands, among which California (17.81%), Texas (10.98%), Florida (7.65%) and New York (6.04%) are the four most populated states. The loans are within 332 MSAs, with Los Angeles, CA, New York City, NY and Dallas, TX accounting for over 3 percent each.

In terms of loan numbers, the most populated property type is multifamily, which accounts for almost one-third of the sample (see Table 9). Retail and office also have significant shares. Table 10 shows characteristics of loans at origination. Original LTVs vary from less than 1% to 113%. As usually seen, most of these commercial mortgage

loans have prepayment constraints, and lockout covers nearly 50 percent of the maturity terms (see Table 11).

We identify 912 defaults (defined as over 60 days of delinquency), which is 3.24% of the whole sample (see Table 12). This is much higher than residential default rate in a 9-year horizon (1995-2003). The sample only contains 2.37% prepayments, which is much lower than prepayment rate in residential mortgages. This could be mainly because of the prepayment constraint in commercial mortgages.

Figure 1 plots the empirical conditional default probabilities at various seasoning (measured in months) of the pool, comparing to the residential default rate benchmark – the 100% SDA. The default probabilities in our sample in most periods are two to three times of the 100% SDA, which demonstrates that commercial mortgages could be much riskier than residential mortgages.

Table 13 reports means and variances of time varying variables at origination and at termination. The intrinsic values of call and put exercises are calculated following Deng, Quigley and Van Order (2000), and the volatility of 10 year treasury security rate, credit spread and credit spread volatility are calculated following Ambrose and Sanders (2003). Specifically, the intrinsic value of call exercise is calculated as the ratio of present values of remaining mortgage payment based on market mortgage rate and on coupon rate. For calculating the intrinsic value of put exercise, we use the National Association of Real Estate Investment Trusts (NAREIT) REITs index by property type to approximate the property value process of each loan, and then calculate the ratio of present value of remaining mortgage payment based on market mortgage rate and property value. The put exercise value is just this ratio minus 1. Volatility of the 10-year

treasury rate is defined as the standard deviation of the 10-year rate measured over the past 24 months. Figure 2 shows the treasury rates and yield curve during our study period, and figure 3 shows the volatility of the 10-year treasury rate. Credit spread is defined as the spread between AAA and Baa rated corporate bond yields, and credit spread volatility is calculated similar to the volatility of the 10-year treasury rate. Figure 4 and 5 plot the credit spread and credit spread volatility. State level monthly unemployment rate from the BLS are matched into our data. The variable prepayment constraint is a time varying dummy variable indicating, in each month, whether the mortgage is covered by any type of prepayment constraint – lock out, yield maintenance or prepayment penalty. We see that the average put option value for defaulted loans is significantly higher than loans at large.

We estimate a flexible baseline hazard model following Deng, Quigley and Van Order (2000) for default risk. We only focus this analysis on default risk due to the following two reasons: first, prepayment is very rare in commercial mortgage as seen in our sample; second, theoretically prepayment has little impact on subordination[18]. Table 14 presents the maximum likelihood estimates.

The value of put option exercise is highly significant for default, and it has a positive sign as we expect. Different from the competing risks story in residential mortgages, the value of call option is positively related to default exercise. This is possibly because given prepayment constraint and distressed loans workout practice in commercial mortgages, some borrowers could simply choose to default when it's optimal to refinance and they could get a new mortgage to pay off the principal when original

[18] In fact, rating agencies do not consider prepayment risk in subordination design since it is not a credit issue.

lender/servicer comes to "workout" the loan[19]. Credit spread and unemployment rate, which are good proxies for overall and local economic environments respectively, are significant and have positive effect on default. For different property types, hotel loans have higher default rates, other things being equal. Office loans have lower default rates. It is interesting that multifamily loans do not show lower default rates with statistical significance, which may be consistent with our previous results of deal subordination. Loans in Midwest and in Southern part of the country are riskier, while those in Western/Southern Pacific, including California, have lower default risks. This is consistent with regional real estate market performance.

Consistent with the existing literature, original LTV does not have a positive impact on default risk. We also analyze the correlations of original LTV and put and call values. We find that the correlations are very low, which exclude the possibility that the values of put and call exercises capture the effect of original LTV on default risk.

Our final goal is to directly link subordination to CMBS pool credit risk. We use the default probability model estimated above to predict conditional default probabilities for each loan over 85-month period. We then calculate cumulative default probabilities in each month. The cumulative default rate in the first year is about 0.1 percent and it grows to over 2 percent in year 3 and over 4 percent in year 5 (see Table 15).

Next, we calculate expected losses of each loan over certain horizons based on loss severity assumptions documented in the Appendix table. Then, we aggregate loan level expected losses into CMBS deal level. Table 16 shows the expected losses of the 174 CMBS deals at 1 year, 2 year, 3 year, 5 year and 7 year.

[19] Although this is not legal practice, it is not rare.

Finally, we regress AAA and BBB subordination levels of CMBS deals on the 2-year, 3-year, 5-year and 7-year expected losses respectively. In table 17 (panel 1 for AAA subordination and panel 2 for BBB subordination), we do see that the 2-year, 3-year, 5-year and 7-year expected losses are all have significant positive correlation with subordination.

However, we find the fittings of above models range from 8 percent to 34 percent, which implies that over 65 percent of subordination variation is not explained by the expected losses predicted by our model. Stated differently, CMBS deals with higher AAA and/or BBB subordination do not necessary expect higher default loss. This suggests that it is difficult to establish a deterministic relationship between subordination levels and default loss, a priori, and that investors need to pay close attention in discerning different deals.

6. Conclusion

Subordination plays an important role in the senior-subordinated structure of securitized transactions such as CMBS. Optimal subordination design is in the interests of CMBS investors, issuers and financial economists because subordination levels provide guidance to investors when buying senior CMBS bonds which are protected from credit risk. They also determine how much senior bond an issuer can get out of a certain commercial mortgage pool. Rating agencies determine subordination levels at deal cutoff. Typically, the CMBS issuer assembles a pool of loans and passes the information of these loans to rating agencies. Rating agencies then work independently to examine how much subordination is needed for the tranches to reach certain ratings, such as AAA, AA, A, BBB etc.

In this paper, we focus on the cross sectional differences in subordination levels among different CMBS deals. We ask two questions: 1) what explains subordination levels? 2) whether CMBS bonds (or tranches) with greater levels of subordination do, in fact, experience higher ex-post levels of delinquencies and default.

We perform both a deal level and a loan level analysis using data on US CMBS securities issued during 1995 and 2005. Our results show that debt service coverage ratio (DSCR) and measures of deal property type composition and prepayment protection are important in subordination design. We also find cutoff year to be significant and verify the trend of contraction of subordination levels over time. Expected loss for CMBS pools is a statistically significant factor in explaining both AAA and BBB bond subordination levels; however, it accounts for less than 35 percent of the variation. This result suggests that it is difficult to establish a deterministic relationship between subordination levels and default loss, a priori.

The study fills the gap of existing studies and provides important information regarding CMBS investment. Rating agencies use their internal models to work with CMBS issuers on subordination design. Therefore, little is known to the public (including investors and financial economists) about how different credit risk and non-credit risk factors affect subordination. We identify those factors in our deal level analysis. Further, our results show that even with same ratings CMBS bonds varies a great deal in default experience. Therefore, CMBS investors should pay close attention to default risk of different bonds in order to differentiate “good” deals from “bad” deals.

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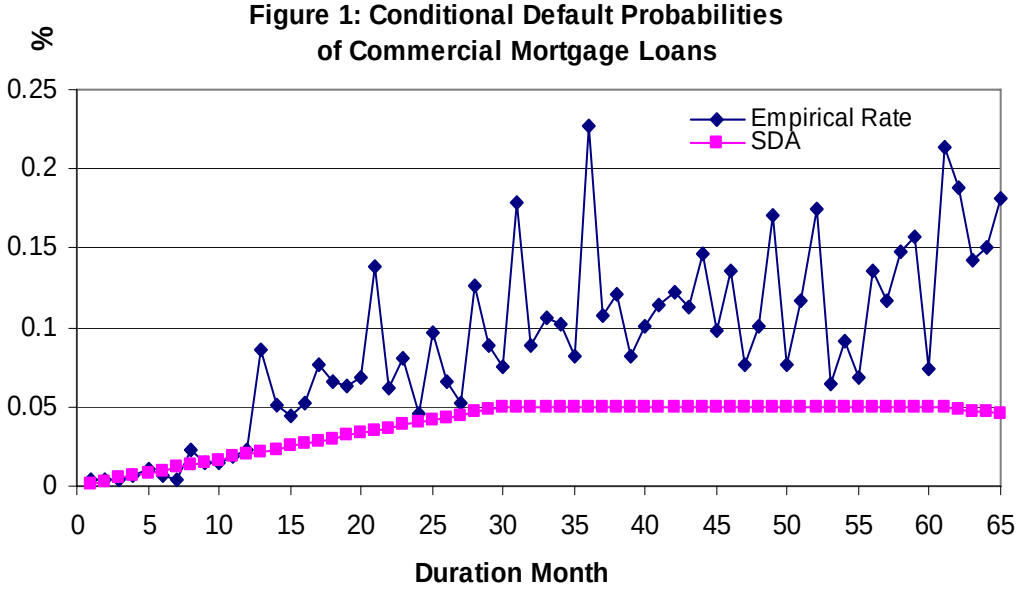
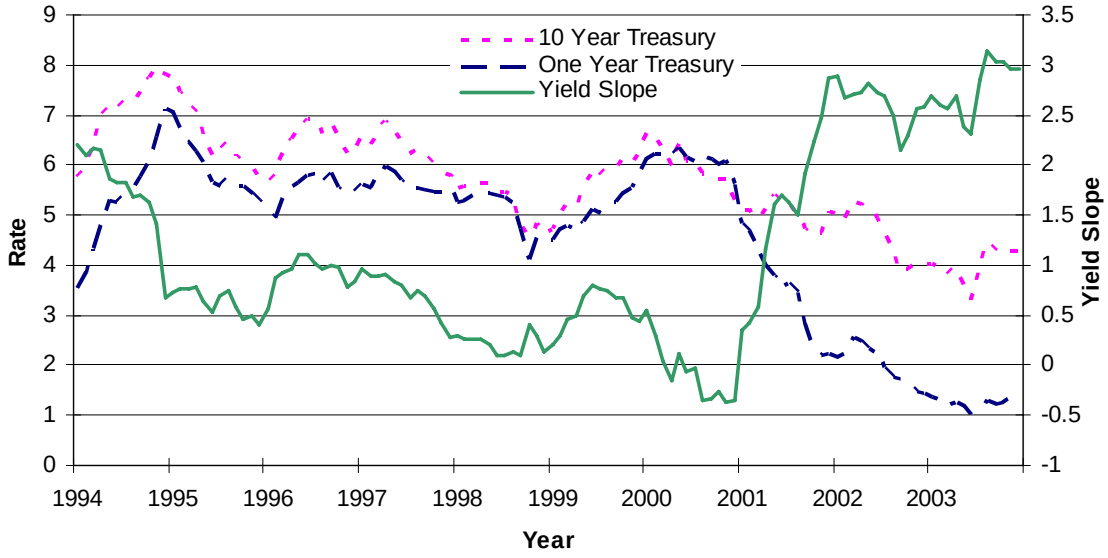
Figure 1: Conditional Default Probabilities of Commercial Mortgage Loans



NOTE: The empirical rate is the conditional default probability of commercial mortgage loans in our sample. The SDA is the Standard Default Assumptions for residential mortgages. The figure shows substantially higher default rates of commercial mortgages comparing to residential mortgages. It also shows the pattern of change in commercial mortgage default rate with respect to duration.

Figure 2: Interest Rates and Yield Slope



NOTE: Yield slope is defined as 10 year treasury rate minus 1 year treasury rate.

Figure 3: Volatility of 10 Year Treasury Rate

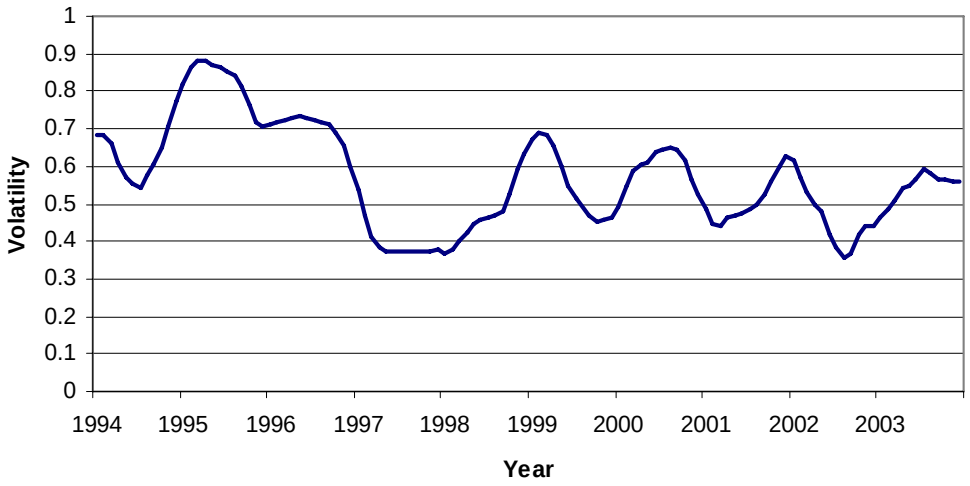
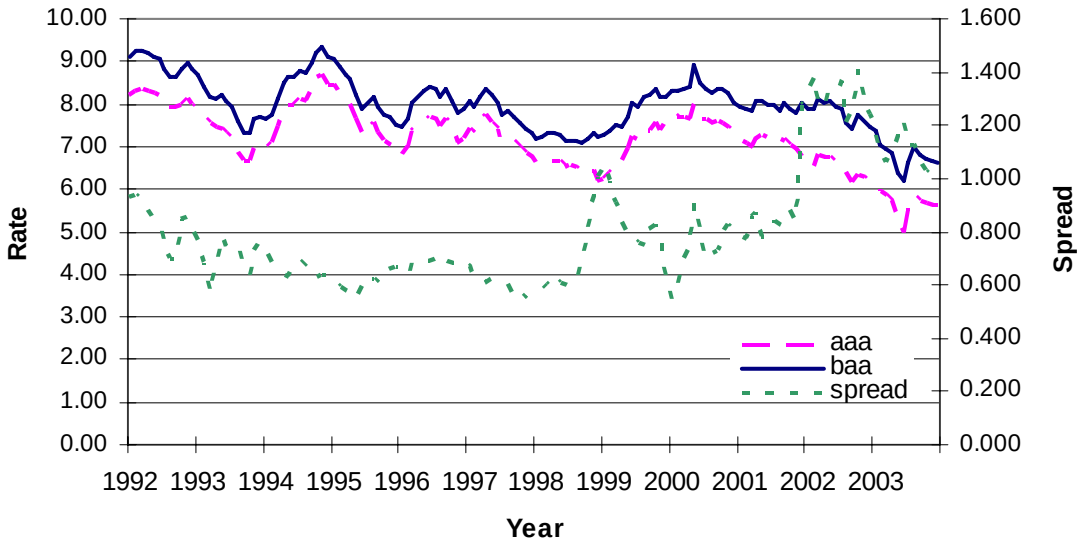


Figure 4: Bond Rates and Credit Spread



NOTE: Credit spread is defined as the difference between AAA corporate bond rate and BAA corporate bond rate.

Figure 5: Volatility of Credit Spread

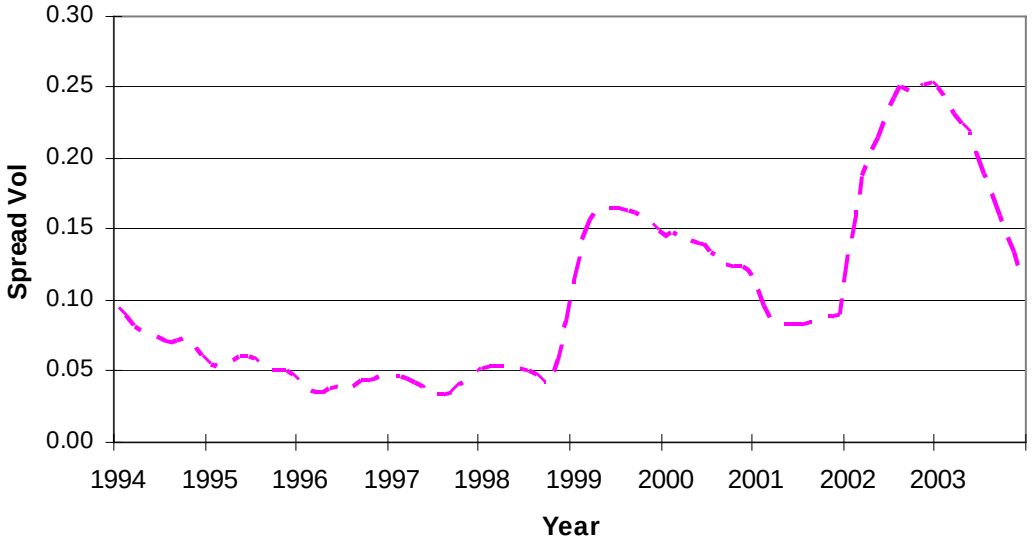


Table 1: Cutoff Year Distribution of the CMBS Conduit Deals in Our Sample

Year	Frequency	Percentage	Percentage of all deals in the year
1995	2	0.57	6.67
1996	10	2.86	19.61
1997	24	6.86	41.38
1998	35	10.00	47.95
1999	37	10.57	44.58
2000	30	8.57	44.78
2001	40	11.43	66.67
2002	38	10.86	63.33
2003	56	16.00	62.92
2004	62	17.71	63.27
2005	16	4.57	76.19
Total	350	100	

NOTE: All data are from CMBS.com. Data collecting date is April 1, 2005. The above 350 deals are conduit deals with all fixed rate loans underlying the deals.

Table 2: Descriptive Statistics of Our Sample Deals

Variable	Mean	Std Dev.	Minimum	Maximum
Number of assets at cutoff	150	78	28	664
Deal cutoff balance (000s)	1,110,103	514,808	77,962	3,722,686
AAA subordination	0.21	0.06	0.09	0.37
BBB subordination	0.08	0.03	0.02	0.17
Cutoff LTV	0.68	0.04	0.43	0.77
Cutoff DSCR	1.57	0.25	0.92	3.13
Estimated LTV at maturity	0.57	0.08	0.22	1.54
Over-collateralization	0.02	0.08	0.00	0.83
Share of multifamily loans (in $)	0.21	0.12	0.00	1.00
Share of retail, anchored loans	0.26	0.13	0.00	0.64
Share of retail, unanchored loans	0.07	0.08	0.00	0.65
Share of office loans	0.24	0.12	0.00	0.59
Share of industrial loans	0.08	0.05	0.00	0.32
Share of healthcare loans	0.01	0.05	0.00	0.82
Share of full service hotel loans	0.03	0.04	0.00	0.18
Share of limited service hotel loans	0.03	0.05	0.00	0.39
Share of self-storage space loans	0.02	0.03	0.00	0.27
Share of mixed use property loans	0.03	0.04	0.00	0.31
Share of mobile home loans	0.03	0.03	0.00	0.19
Share of warehouse loans	0.01	0.02	0.00	0.19
Share of other property loans	0.00	0.01	0.00	0.09
Share of amount of the largest loan	0.09	0.06	0.02	0.40
Share of amount of the 5 largest loan	0.27	0.10	0.09	0.66
Yield Maintenance coverage	0.58	0.23	0.05	0.96
Lock out coverage	0.28	0.24	0.00	0.91
Defeasance coverage	0.51	0.26	0.00	0.94
Number of deals		350		

NOTE: Cutoff LTV and cutoff DSCR are from the CMBS.com database, which are calculated as weighted average of loan LTV and DSCR of all loans in each specific CMBS pool at cutoff. Estimated LTV at maturity is also from CMBS.com, and is a proxy measure of balloon risk.

Table 3: CMBS Conduit Deals Matched with Commercial Mortgage Loans

Deal Name	Loan Number	Percent	Deal Name	Loan Number	Percent
AMRESCO 1997-C1	96	0.34	GMAC 1999-C3	138	0.49
ASC 1995-D1	61	0.22	GSMSCII 2003-C1	74	0.26
ASC 1996-D2	124	0.44	GSMSCII 1999-C1	304	1.08
ASC 1996-D3	114	0.40	HMAC 2000-PH1	235	0.83
BACM 2000-2	128	0.45	HMAC 1999-PH1	181	0.64
BACM 2001-PB1	134	0.47	JPMCC 2001-C1	169	0.60
BACM 2002-PB2	118	0.42	JPMCC 2001-CIBC3	125	0.44
BACM 2003-1	112	0.40	JPMCC 2002-C1	129	0.46
BSCMS 2000-WF1	181	0.64	JPMCC 2002-C2	108	0.38
BSCMS 2000-WF2	145	0.51	JPMCC 2002-C3	87	0.31
BSCMS 2001-TOP2	140	0.50	JPMCC 2002-CIBC4	121	0.43
BSCMS 2001-TOP4	152	0.54	JPMCC 2002-CIBC5	116	0.41
BSCMS 2002-PBW1	126	0.45	JPMCC 2003-C1	103	0.36
BSCMS 2002-TOP6	150	0.53	JPMCC 2003-ML1	122	0.43
BSCMS 2002-TOP8	120	0.42	JPMC 2000-C10	168	0.59
BSCMSI 1998-C1	146	0.52	JPMCC 2001-CIBC1	165	0.58
BSCMSI 1999-C1	114	0.40	JPMCC 2001-CIBC2	143	0.51
BSCMSI 1999-WF2	285	1.01	JPMC 2000-C9	140	0.50
CASC 1998-D7	199	0.70	JPM 1997-C5	269	0.95
CCA1-2	92	0.33	JPM 1999-C7	145	0.51
CCA1-3	108	0.38	JPM 1999-C8	128	0.45
CCMSC 2000-1	91	0.32	JPMC 1999-PLS1	65	0.23
CCMSC 2000-2	81	0.29	LBCC 1996-C2	109	0.39
CCMSC 2000-3	95	0.34	LBCMT 1998-C1	259	0.92
CCMSC 1999-2	92	0.33	LBUBS 2000-C3	173	0.61
CDCMT 2002-FX1	58	0.21	LBUBS 2000-C4	167	0.59
CMAC 1998-C1	312	1.10	LBUBS 2000-C5	110	0.39
CMAC 1999-C1	242	0.86	LBUBS 2001-C2	141	0.50
CMAT 1999-C1	230	0.81	LBUBS 2001-C3	134	0.47
CMAT 1999-C2	81	0.29	LBUBS 2001-C7	114	0.40
CMB-FUNB 1999-1	205	0.73	LBUBS 2002-C1	142	0.50
CMLBC 2001-CMLB-1	120	0.42	LBUBS 2002-C2	111	0.39
COMM 2000-C1	112	0.40	LBUBS 2002-C4	114	0.40
COMM 1999-1	221	0.78	MCFI 1996-MC1	162	0.57
CSFB 2000-C1	211	0.75	MCFI 1997-MC1	158	0.56
CSFB 2001-CF2	182	0.64	MCFI 1997-MC2	181	0.64
CSFB 2001-CK1	142	0.50	MCFI 1998-MC1	249	0.88
CSFB 2001-CK3	169	0.60	MCFI 1998-MC3	232	0.82
CSFB 2001-CKN5	195	0.69	MLFA 2001-CAN5	55	0.19
CSFB 2001-CK6	240	0.85	MLMI 1996-C2	300	1.06
CSFB 2001-CP4	130	0.46	MLMI 1997-C1	219	0.77
CSFB 2002-CKP1	156	0.55	MLMI 1997-C2	147	0.52
CSFB 2002-CKN2	204	0.72	MLMI 1998-C2	401	1.42
CSFB 2002-CKS4	156	0.55	MLMI 1998-C3	139	0.49
CSFB 2002-CP3	103	0.36	MLFA 1998-CAN1	32	0.11
CSFB 2002-CP5	141	0.50	MLMI 1999-C1	106	0.37
CSFB 2003-CK2	101	0.36	MLFA 1999-CAN2	43	0.15

CSFB 1995-M1	28	0.10	MLMT 2002-MW1	101	0.36
CSFB 1999-C1	152	0.54	MSCI 2000-LIFE1	131	0.46
DLJ 2000-CF1	128	0.45	MSCI 1996-WF1	148	0.52
DLJCMC 2000-CKP1	230	0.81	MSCI 1997-C1	160	0.57
DLJ 1997-CF1	118	0.42	MSCI 1997-HF1	169	0.60
DLJ 1997-CF2	126	0.45	MSCI 1997-WF1	126	0.45
DLJ 1998-CF2	302	1.07	MSCI 1998-CF1	323	1.14
DLJ 1998-CG1	301	1.06	MSCI 1998-HF2	262	0.93
DLJ 1999-CG2	343	1.21	MSCI 1998-HF1	351	1.24
DLJ 1999-CG3	160	0.57	MSCI 1998-WF1	299	1.06
FUBOA 2001-C1	182	0.64	MSCI 1998-WF2	218	0.77
FULB 1997-C1	283	1.00	MSCI 1999-FNV1	166	0.59
FULB 1997-C2	421	1.49	MSCI 1999-RM1	221	0.78
FUNB 2000-C1	143	0.51	MSCI 1999-WF1	266	0.94
FUNB 2000-C2	162	0.57	MSDWC 2001-PPM	84	0.30
FUNB 2001-C2	107	0.38	MSDWC 2001-TOP1	165	0.58
FUNB 2001-C3	125	0.44	MSDWC 2001-TOP3	158	0.56
FUNB 2001-C4	137	0.48	MSDWC 2001-TOP5	143	0.51
FUNB 2002-C1	106	0.37	NFC 1998-1	201	0.71
FUNB-CMB 1999-C2	223	0.79	NFC 1998-2	376	1.33
FUNB 1999-C4	156	0.55	NFC 1999-1	331	1.17
GCCFC 2002-C1	112	0.40	PCMT 2003-PWR1	100	0.35
GECCMC 2000-1	102	0.36	PMAC 1999-C1	177	0.63
GECCMC 2001-1	151	0.53	PNCMA 2000-C1	209	0.74
GECCMC 2001-2	126	0.45	PNCMAC 2000-C2	185	0.65
GECMC 2001-3	133	0.47	PNCMAC 1999-CM1	207	0.73
GECMC 2002-1	137	0.48	PSSFC 1998-C1	254	0.90
GECCMC 2002-2	111	0.39	PSSFC 1999-C2	220	0.78
GECCMC 2002-3	131	0.46	PSSFC 1999-NRF1	257	0.91
GECCMC 2003-C1	134	0.47	RMF 1997-1	48	0.17
GMAC 2000-C1	136	0.48	SBM7 2002-KEY2	66	0.23
GMAC 2000-C2	129	0.46	SBMS 2000-C1	266	0.94
GMAC 2000-C3	174	0.62	SBMS 2000-C3	181	0.64
GMAC 2001-C1	101	0.36	SBMS 2001-C1	182	0.64
GMAC 2001-C2	96	0.34	SBMS 2001-C2	139	0.49
GMAC 2002-C1	108	0.38	SBMS 1999-C1	213	0.75
GMAC 2002-C2	109	0.39	WBCMT 2002-C1	156	0.55
GMAC 2002-C3	108	0.38	WBCMT 2002-C2	104	0.37
GMAC 2003-C1	104	0.37	WBCMT 2003-C3	130	0.46
GMAC 1997-C1	355	1.26	WBCMT 2003-C4	140	0.50
			Total (174 deals)	**28,124**	**100.00**

Table 4: Matched CMBS Conduit Deals by Cutoff Year

Year	Frequency	Cumulative Frequency	Percent	Cumulative Percent
1995	2	2	1.15	1.15
1996	6	8	3.45	4.6
1997	16	24	9.2	13.79
1998	20	44	11.49	25.29
1999	30	74	17.24	42.53
2000	27	101	15.52	58.05
2001	33	134	18.97	77.01
2002	30	164	17.24	94.25
2003	10	174	5.75	100

NOTE: The 174 deals are associated with 28,124 commercial mortgage loans. All deals are conduit deals, with all fixed rate loans.

Table 5: Matched Commercial Mortgage Loans by Origination Year

	Number of loans	Cumulative number	Percent	Cumulative Percent
1994	52	52	0.18	0.18
1995	269	321	0.96	1.14
1996	1,407	1,728	5.00	6.14
1997	4,025	5,753	14.31	20.46
1998	7,133	12,886	25.36	45.82
1999	4,027	16,913	14.32	60.14
2000	3,346	20,259	11.90	72.03
2001	4,151	24,410	14.76	86.79
2002	2,909	27,319	10.34	97.14
2003	805	28,124	2.86	100.00

NOTE: These are commercial mortgage loans underlying the 174 CMBS conduit deals.

Table 6: Estimates of the CMBS Deal Subordination Models
Dependent variable: AAA/BBB subordination at cut off

	AAA subordination		BBB subordination	
	Model 1	Model 2	Model 1	Model 2
Intercept	0.436***	0.431***	0.184***	0.173***
	(0.018)	(0.018)	(0.009)	(0.01)
Cutoff DSCR	-0.145***	-0.034***	-0.069***	-0.014***
	(0.012)	(0.006)	(0.006)	(0.004)
Estimated LTV at Maturity		0.029		0.011
		(0.018)		(0.01)
Over-collateralization		0.016		0.027*
		(0.02)		(0.012)
Share of retail, anchored loans		-0.072***		-0.009
		(0.016)		(0.009)
Share of retail, unanchored loans		-0.028		-0.016
		(0.022)		(0.013)
Share of office loans		-0.051**		-0.022
		(0.016)		(0.009)
Share of industrial loans		-0.214***		-0.049**
		(0.032)		(0.018)
Share of healthcare loans		0.012		0.031
		(0.028)		(0.016)
Share of full service hotel loans		0.022		-0.006
		(0.037)		(0.021)
Share of limited service hotel loans		0.034		0.063***
		(0.033)		(0.019)
Share of self-storage property loans		0.109*		0.051
		(0.054)		(0.031)
Share of mixed-use property loans		-0.028		0.028
		(0.032)		(0.018)
Share of mobile home loans		0.000		0.034
		(0.042)		(0.024)
Share of warehouse loans		-0.151*		-0.102**
		(0.066)		(0.038)
Share of other loans		0.244*		-0.099
		(0.11)		(0.063)
The largest loan weights over 15%		0.001		-0.003
		(0.005)		(0.003)
Share of top 5 loans		-0.074***		-0.046***
		(0.02)		(0.011)
Yield maintenance coverage		-0.279***		-0.159***
		(0.022)		(0.013)
Lock out coverage		-0.002		0.002
		(0.006)		(0.004)
Defeasance coverage		0.085***		0.061***
		(0.02)		(0.011)
N	350	350	350	350
Adjusted R-Square	0.3079	0.8707	0.2863	0.8273

NOTE: These are OLS estimates. Standard errors are in parentheses. *** for p<0.001; ** for p<0.01; * for p<0.05. We exclude from the regressions some deal level information such as cut of LTV, number of loans, and cut off balance because of multi-collinearity problem.

Table 7: Estimates of the CMBS Deal Subordination Models with Time Trend
Dependent variable: AAA/BBB subordination at cut off

	AAA Subordination		BBB Subordination	
	Model 1	Model 2	Model 1	Model 2
Intercept	0.413***	0.403***	0.167***	0.165***
	(0.016)	(0.017)	(0.01)	(0.011)
Cutoff DSCR	-0.031***	-0.038***	-0.013***	-0.014***
	(0.006)	(0.006)	(0.003)	(0.004)
Estimated LTV at Maturity	0.048**	0.035*	0.017	0.018
	(0.016)	(0.015)	(0.01)	(0.01)
Over-collateralization	0.015	0.019	0.027*	0.031**
	(0.018)	(0.017)	(0.011)	(0.011)
Share of retail, anchored loans	-0.064***	-0.065***	-0.007	-0.010
	(0.014)	(0.014)	(0.009)	(0.009)
Share of retail, unanchored loans	-0.040*	-0.048*	-0.020	-0.020
	(0.02)	(0.019)	(0.012)	(0.012)
Share of office loans	-0.035*	-0.030*	-0.016	-0.016
	(0.014)	(0.014)	(0.009)	(0.009)
Share of industrial loans	-0.189***	-0.182***	-0.041*	-0.044*
	(0.029)	(0.028)	(0.018)	(0.018)
Share of healthcare loans	0.021	0.015	0.034*	0.046**
	(0.025)	(0.025)	(0.015)	(0.016)
Share of full service hotel loans	-0.008	-0.010	-0.015	-0.006
	(0.034)	(0.033)	(0.021)	(0.021)
Share of limited service hotel loans	-0.052	-0.050	0.035	0.038
	(0.031)	(0.03)	(0.019)	(0.019)
Share of self-storage property loans	0.113*	0.119*	0.052	0.070*
	(0.049)	(0.047)	(0.03)	(0.03)
Share of mixed-use property loans	0.003	0.012	0.038*	0.030
	(0.029)	(0.028)	(0.018)	(0.018)
Share of mobile home loans	-0.035	-0.030	0.022	0.016
	(0.038)	(0.037)	(0.023)	(0.024)
Share of warehouse loans	-0.101	-0.032	-0.086*	-0.078*
	(0.06)	(0.058)	(0.037)	(0.038)
Share of other loans	0.197*	0.080	-0.114	-0.127*
	(0.1)	(0.095)	(0.061)	(0.062)
The largest loan weights over 15%	-0.003	-0.006	-0.004	-0.004
	(0.005)	(0.005)	(0.003)	(0.003)
Share of top 5 loans	-0.058**	-0.046*	-0.041***	-0.040***
	(0.018)	(0.018)	(0.011)	(0.012)
Yield maintenance coverage	-0.096**	-0.117***	-0.099***	-0.086***
	(0.029)	(0.03)	(0.018)	(0.02)
Lock out coverage	-0.002	0.003	0.002	0.001

	(0.006)	(0.007)	(0.003)	(0.004)
Defeasance coverage	0.049**	0.063***	0.049***	0.042***
	(0.018)	(0.018)	(0.011)	(0.012)
Time trend	-0.015***		-0.005***	
	(0.002)		(0.001)	
YR 97		-0.004		-0.015**
		(0.008)		(0.005)
YR 98		-0.005		-0.012*
		(0.008)		(0.005)
YR 99		-0.028***		-0.017**
		(0.008)		(0.005)
YR 00		-0.063***		-0.025***
		(0.01)		(0.006)
YR 01		-0.075***		-0.029***
		(0.011)		(0.007)
YR 02		-0.073***		-0.031***
		(0.012)		(0.008)
YR 03		-0.089***		-0.037***
		(0.013)		(0.009)
YR 04		-0.110***		-0.047***
		(0.015)		(0.01)
YR 05		-0.122***		-0.053***
		(0.017)		(0.011)
N	350	350	350	350
Adjusted R-Square	0.8944	0.9073	0.8374	0.8396

NOTE: These are OLS estimates. Standard errors are in parentheses. *** for p<0.001; ** for p<0.01; * for p<0.05. We exclude from the regressions some deal level information such as cut of LTV, number of loans, and cut off balance because of multi-collinearity problem.

Table 8: Regional Distribution of the Matched Commercial Mortgage Loans

Region	Number of loans	Percent
Midwest/Eastern	2,708	9.63
Midwest/Western	1,056	3.75
Northeast/Mid-Atlantic	3,259	11.59
Northeast/New England	1,308	4.65
Southern/Atlantic	5,875	20.89
Southern/East Coast	916	3.26
Southern/West Coast	3,675	13.07
Western/Mountain	2,669	9.49
Western/Northern Pacific	2,353	8.37
Western/Southern Pacific	3,497	12.43
Missing	808	2.87
Total	28,124	100

Table 9: Property Type Composition of the Commercial Mortgage Loans

	Number of loans	Percent
Multifamily	8,871	31.54
Retail	7,746	27.54
Office	4,186	14.88
Industrial	2,401	8.54
Hotel	1,495	5.32
Other	3,425	12.18
Total	28,124	100

Table 10: Characteristics of the Commercial Mortgage Loans at Origination

Variable	Mean	Std Dev.	Minimum	Maximum
Original Balance (000s)	$5,857.41	$9,362.98	$67.48	$295,000.00
Original LTV (%)	69.02	11.54	0.66*	112.50
Gross coupon rate (%)	7.76	0.86	4.35	12.88
Net coupon rate (%)	7.68	0.84	4.23	12.78
Amortization term (months)	324.54	52.34	33.00	720.00
Maturity term (months)	128.07	35.36	33.00	360.00
Number of loans		28,124		

NOTE: * There are 4 loans with abnormally low (less than 5 percent) original LTV. We set their original LTV values to sample mean when running the model.

Table 11: Prepayment Constraint Coverage of the Commercial Mortgage Loans

Variable	Month	Coverage
Maturity Term	3,601,947	
Lockout	1,702,134	47.26
Yield Maintenance	692,094	19.21
Prepayment Penalty	70,458	1.96

NOTE: Unfortunately, we don't have defeasance term recorded in our loan level data.

Table 12: Termination Status of the Commercial Mortgage Loans

	Frequency	Percent
Default	912	3.24
Prepay	667	2.37
Mature	51	0.18
Current	26,494	94.20
Total	28,124	100

NOTE: Default is defined as over 60 days of delinquency, rather than real foreclosure. Status observation point is June 1, 2003.

Table 13: Descriptive Statistics of Time Varying Variables

	At Origination				At Termination			
Variable	All loans		Defaulted loans		All loans		Defaulted loans	
	Mean	Variance	Mean	Variance	Mean	Variance	Mean	Variance
Call option	0.024	0.002	0.047	0.002	0.153	0.003	0.111	0.005
Call option square	0.003	0.000	0.004	0.000	0.027	0.000	0.017	0.000
Put option	-0.551	3.123	-0.400	0.050	-1.083	4.481	-0.638	0.293
Put option square	3.427	21178	0.210	0.105	5.653	37240	0.699	1.135
Vol. of 10 year treasury	0.854	0.819	0.525	0.209	2.349	0.165	1.658	1.253
Credit spread	0.800	0.052	0.698	0.017	1.150	0.010	1.002	0.061
Vol. of credit spread	0.102	0.004	0.078	0.002	0.212	0.001	0.153	0.004
Unemployment rate	4.827	1.298	4.567	1.065	5.812	0.847	5.109	1.416
Prepayment constraint	0.994	0.007	0.997	0.003	0.843	0.132	0.907	0.085
Number of loans	28,124		912		28,124		912	

NOTE: Call option value is calculated as the percent difference between the present value of existing mortgage payment stream under current market rate and present value under mortgage coupon rate. Put option value is calculated as the percent difference between the current market value of the mortgage and the current market value of the property. Current property market value is estimated using the National Real Estate Investment Trusts (NAREIT) property value index. Credit spread is defined as the yield differential between AAA corporate bonds and BAA corporate bonds, and its volatility is approximated by its standard deviation in the past 24 month. Volatility of 10 year treasury rate is calculated similarly. Prepayment constraint is a time varying dummy variable. In each month, we examine whether the loan is covered by any one of the prepayment constraints (lockout, yield maintenance and prepayment penalty). If so, the prepayment constraint is assigned a value of 1. Unemployment rate is the state unemployment rate obtained from the Bureau of Labor Statistics (BLS).

Table 14: Maximum Likelihood Estimates of the Flexible Baseline Default Models

	Model 1	Model 2
Original LTV	-0.01	-0.01
	(0.01)	(0.01)
Call option	9.00***	8.66***
	(1.19)	(1.23)
Call option square	-11.18**	-8.12
	(5.38)	(5.54)
Put option	0.49***	0.54***
	(0.13)	(0.12)
Put option square	0.00	0.00
	(0.05)	(0.04)
Vol. of 10 year treasury		0.22
		(0.22)
Credit spread		1.64***
		(0.47)
Vol. of credit spread		-3.44***
		(0.79)
Unemployment rate		0.08**
		(0.04)
Prepayment constraint		-0.49***
		(0.12)
Multifamily dummy	-0.20	-0.20
	(0.13)	(0.13)
Retail dummy	0.10	0.09
	(0.13)	(0.13)
Office dummy	-0.30*	-0.30*
	(0.16)	(0.16)
Industrial dummy	0.20	0.21
	(0.16)	(0.16)
Hotel dummy	0.92***	0.83***
	(0.15)	(0.15)
Midwest/Eastern	0.66***	0.70***
	(0.16)	(0.16)
Midwest/Western	0.46**	0.56***
	(0.2)	(0.22)
Northeast/Mid-Atlantic	0.18	0.20
	(0.16)	(0.17)
Northeast/New England	0.12	0.24
	(0.21)	(0.23)
Southern/Atlantic	0.38***	0.44***
	(0.14)	(0.15)
Southern/East Coast	0.77***	0.80***
	(0.18)	(0.19)
Southern/West Coast	0.55***	0.56***
	(0.15)	(0.15)
Western/Mountain	0.17	0.22
	(0.17)	(0.17)
Western/Southern Pacific	-0.74***	-0.76***

	(0.2)	(0.21)
Likelihood	-31,013	-30,977
B.I.C.	62,476	62,425
A.I.C.	62,228	62,166
N	28,124	28,124

NOTE: Standard errors are in parentheses. *** for p<0.001; ** for p<0.01; * for p<0.05. The hazard model is estimated using maxim likelihood method as in Deng, Quigley and Van Order (2000). A flexible baseline is estimated simultaneously with other covariates. For property types, we use the "other" type as the reference group, and for regional dummy we use "Western/Northern Pacific" as the reference group.

Table 15: Predicted Cumulative Default Rate of Commercial Mortgage Loans

	Mean	Std Dev.	Minimum	Maximum
1 year cum. default rate	0.14	0.13	0.00	2.08
2 year cum. default rate	0.95	0.93	0.00	12.67
3 year cum. default rate	2.08	1.85	0.00	20.69
5 year cum. default rate	4.08	3.23	0.02	34.99
7 year cum. default rate	6.45	4.30	0.20	44.25
Number of deals		28,124		

NOTE: The numbers are in percent. We use the estimated model 2 in table 13 to predict the hazard rate in each of the 85 duration month for each loan. We then calculate the cumulative default rates for each loan. Insignificant variables like "original LTV" are dropped from the prediction equation.

Table 16: Expected Cumulative Loss of CMBS Pools

	Mean	Std Dev.	Minimum	Maximum
1 year expected cum. loss	0.06	0.03	0.02	0.31
2 year expected cum. loss	0.41	0.21	0.11	1.38
3 year expected cum. loss	0.91	0.43	0.37	2.53
5 year expected cum. loss	1.75	0.71	0.93	4.80
7 year expected cum. loss	2.75	0.95	1.68	7.27
Number of deals		174		

NOTE: The numbers are in percent. Expected loss is just default probability times loss given default. Our loss given default assumptions follow Moody's study on loss severity, which assigns different loss ratios for different types of properties. See Appendix table for details. We aggregate expected loss for each loan into CMBS deal level.

Table 17: Estimates of the Subordination – Expected Loss Relationship Models
Dependent variable: AAA/BBB subordination level of CMBS deal

Panel 1: AAA subordination	Model 1	Model 2	Model 3	Model 4
Intercept	0.21***	0.21***	0.18***	0.17***
	(0.01)	(0.01)	(0.01)	(0.01)
2 year expected cum. loss	6.85***			
	(1.66)			
3 year expected cum. loss		3.80***		
		(0.81)		
5 year expected cum. loss			3.56***	
			(0.45)	
7 year expected cum. loss				2.79***
				(0.33)
N	174	174	174	174
Adjusted R-Square	0.0845	0.1076	0.2658	0.2941

Panel 2: BBB subordination	Model 1	Model 2	Model 3	Model 4
Intercept	0.08***	0.07***	0.06***	0.05***
	(0.00)	(0.00)	(0.00)	(0.00)
2 year expected cum. loss	3.82***			
	(0.79)			
3 year expected cum. loss		2.27***		
		(0.38)		
5 year expected cum. loss			1.89***	
			(0.21)	
7 year expected cum. loss				1.45***
				(0.15)
N	174	174	174	174
Adjusted R-Square	0.1143	0.1673	0.3197	0.3411

NOTE: Standard errors are in parentheses. *** for p<0.001; ** for p<0.01; * for p<0.05. These are OLS estimates.

Appendix Table: Loss Severity Assumptions Used in CMBS Pool Expected Loss Calculations

Property type	Loss ratio (%)
Multifamily	32.3
Retail	43.6
Office	38.1
Industrial	35.0
Hotel	52.5
Other	60.6

NOTE: This is based on Moody's study of historical loss ratios of commercial mortgages.