THE ROLE OF CORRELATION IN THE CURRENT CREDIT RATINGS SQUEEZE

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Abstract

A current matter of preoccupation is the financial crisis in the US, and Europe. This event is the consequence of a large number of credit rating downgrades in AAA structures of mortgages that have affected the US real estate industry since March 2007. This paper focuses on one aspect of credit risk analysis: the importance of default correlation in measuring credit risk in subprime portfolios as a key variable in the current financial crisis. We show empirically how different estimates of such correlation coefficient impact the sigmas of the portfolio of assets significantly. We propose three reasons to explain the underestimation of these coefficients in the past. This paper supports the idea that better understanding of the correlations implied within subprime loan portfolios would help rating companies, lenders, and regulators improve their evaluation of default risks.

Keywords

Credit risk, subprime, correlation, structured finance

1. Introduction

During the last few months, a topic of discussion in the financial press has been the subprime mortgage financial crisis, which has yet to be resolved. The crisis developed subsequent to an unprecedented increase in the number of foreclosures in the subprime mortgage market. As doubts about the extent of the crises began to mount, market participants concerns' spread provoking a downfall in the stock prices of companies within the subprime mortgage industry, and some large lenders. The subsequent flight to safety resulted in additional liquidity concerns. At the peak of the crises, several large subprime mortgage lenders shut down or filed for bankruptcy, and a number of hedge funds become worthless[i]. Originally, the crisis affected the US market. Nevertheless, by May 2007, worries over the exposures to US mortgages affected financial markets worldwide, and by July the crisis had turned global[ii].

The relevance of the crises triggered by subprime loan lending is better understood when the size of this industry and its interrelations with other sectors of the economy are made clear. As of March, 2007, there were \$6.5 trillion mortgage backed securities in the U.S., of which 20% were subprime. Between July and September of the same year, almost half a million U.S. homes were facing some kind of foreclosure activity, and by October, 16% of the subprime loans with adjustable rate mortgages (ARM) were 90-days into default or in foreclosure proceedings[iii].

Structural and circumstantial reasons have been proposed to explain the sharp increase in the number of foreclosures, and the turmoil ignited around it. Even though the crisis is not over and information is still being analyzed, there seems to be consensus in that rising interest rates, together with a downturn in property values, originated the crises (Jorion, 2007). Nevertheless, in addition, a number of practices, organizations, and institutions have also been blamed for their contribution to the depth and width of the crisis, most notably: predatory lending practices of subprime lenders and discrimination on the basis of race[iv], mortgage brokers encouraging borrowers to take loans they could not afford, the increase in the number of subprime mortgages issued by lenders, appraisers with inflated housing values, borrowers over-stating their incomes and entering into loan agreements they could not fulfil, the offer of adjustable interest rates and deals with low rates that increased sharply after the initial period or payment option loans, Wall Street investors backing up subprime mortgage securities without verifying the strength of the portfolios, rating agencies for either not valuing the risks correctly or not being alert to introduce modifications in their recommendations early enough, and lack of effective government oversight[v].

This paper focuses on the relevance of default correlations as a key variable in this crisis. In our analysis, we use the findings of authors such as Cowan and Cowan (2004), Carey (2000), Gordy (2000), and Jorion (2007) among others, to propose that additional attention should be paid in measuring default correlations within subprime loan portfolios, since these behave in ways that differ from those reported for prime and commercial bonds and loans. This paper strongly supports the idea that improved understanding of the correlations implied within subprime loan portfolios would help rating companies, lenders, and regulators improve their evaluation of default risks.

Background

Subprime lending

Subprime lending refers to the credit status of the loan borrower. Even though there is no official definition that describes a subprime borrower, in 2001 the U.S. Department of Treasury issued the following guideline: "Subprime borrowers typically have weakened credit histories that include payment delinquencies, and possibly more severe problems such as charge-offs, judgments, and bankruptcies. They may also display reduced repayment capacity as measured by credit scores, debt-to-income ratios, or other criteria that may encompass borrowers with incomplete credit histories".[vi]

Therefore, subprime denotes the troubled credit status of the loan borrower. Since these subprime loans have a higher default rate than those within the prime category, these borrowers are considered "higher risk". Consequently, subprime lending applies to a series of credit instruments, such as credit cards, car loans, and mortgages available to a type of borrower that has no access to the general credit market. Because of this risk, a subprime loan is offered at a rate higher than A-paper loans.

Although numerous variables are considered to qualify a loan as subprime, in the United Stated the regulatory benchmark credit score Fair Isaac Corporation (FICO) for subprime is 660, and most people within this credit class have a score under 620 [vii]. The FICO credit score is assigned at the time of origination based on an analysis of a person's credit record. This score represents the likelihood of default, and it is used to decide if and how a person qualifies for a loan[viii]. In addition, along with the credit score, to determine the mortgage rate and credit limit, lenders consider the loan to value ratio[ix]. Current income and employment history do not influence the FICO score, but they are weighed when applying for credit (Chomsisegphet and Pennington-Cross, 2006).

Subprime mortgage loans are a subset of the subprime loan industry[x]. As such, these mortgages are granted to borrowers unable to qualify under more severe criteria. Subprime mortgage loans have a much higher rate of default than prime mortgage loans, and are priced based on the risk assumed by the lender. There are different kinds of subprime mortgages, including: interest-only mortgages; "pick a payment" loans; fixed rate mortgage; negative amortization mortgage; balloon payment mortgage; and adjustable rate mortgages (ARM). All adjustable rates transfer part of the interest rate risk from the lender to the borrower: the borrower benefits if the interest rate falls and loses out if interest rates rise.[xi]

Securitization and Risks

As it has been mentioned, ARMs generally permit borrowers to lower their payments in exchange for accepting the risk of interest rate changes, which is then transferred from the mortgage issuer to the holder. Another way in which mortgage originators control risk, is by selling or securitizing their mortgages.

Securitization is a structured finance process in which certain assets are acquired, grouped into sets, and offered as collateral for third-party investment. Therefore, securitization involves the selling of financial instruments that are backed by the cash flow or value of the underlying assets. Investors "buy" these assets by making loans. To reduce the risk of bankruptcy and obtain lower interest rates from potential lenders, securitization utilizes a special purpose vehicle (SPV). In the real estate industry, securitization is applied to pools of leased property, and in the lending industry, it is applied to lenders' claims on mortgages, home equity loans, student loans, and other debts[xii].

Tranching[xiii] allows the cash flow from the underlying asset to be diverted to the various investor groups. Therefore, this is the mechanism used to generate different investment classes for the securities created in the structured finance world. The addition of all the tranches together make up the deal's capital or liability structure. Tranches with a first claim on the assets are "senior tranches", the safer investments. Tranches with either a second lien or unsecured are the "junior notes". Most often, the more senior rated tranches have higher ratings than the lower rated tranches. However, ratings can fluctuate after the debt is issued, and even senior tranches could be rated below investment grade. Tranches are generally paid sequentially from the most senior to most subordinate, although certain tranches with the same security may be paid at the same time.

The following (see Graph 1 below) is a simplified example of how a typical securitization transaction and tranching works with mortgage backed securities (MBS) as the underlying collateral.

Introduce Graph 1

A bank negotiates hundreds of subprime mortgages with different customers. The bank transfers the risk of the loan portfolio by entering into a default swap with a "ring-fenced" SPV. These mortgages are grouped together in, for example, one $50 million dollar “bucket” to create an MBS. Several of these MBS are pooled together adding up to, let us say, one billion. The one billion dollar asset back security pot is sliced into different tranches. The SPV sells the tranches of credit linked notes with the waterfall structure as in example provided in Table 1:

Introduce Table 1

The equity investors absorb the first loss up to ten percent of the value of the portfolio: out of one hundred equal value mortgages, the first ten that fail. Mezzanine will accept the next losses from ten to forty percent, and senior debt looses only if failures are larger than forty percent. The tranches which absorb the first losses are sold to investors who desire greater returns, while tranche A is destined to investors who are looking for more secured investments.

In summary, through securitization the rights to these mortgage payments have been repackaged into investment securities, such as mortgage-backed securities (MBS) or collateralized debt obligations (CDO). Due to tranching, some of the securities created have a rating higher than the average rating of the underlying collateral asset pool. Therefore, the most senior claims are expected to be insulated from the default risk of the underlying asset pool through the absorption of losses by the more junior claims. That is, a set of bonds with a much lower probability of total default are created. In our example, 40% of the mortgages would need to default before the senior claims would feel any adverse effects.

Although tranching is very useful for the purpose of spreading risks, some of its more problematic side effects have surfaced during the current subprime meltdown. These outcomes are the consequence of the intricacies of evaluating the distribution of losses under every likely state of affairs, as well as the challenge of valuing the risks entrenched in the high-yield debt, and MBS backing the products. This is particularly the case in times when the market value of the underlying assets is decreasing. In many instances, when the asset value is reduced the CDO is asked to liquidate the collateral, further depressing its value, and creating a downward spiral in price depression. Furthermore, the volatility in the value of the collateral linked to the subprime mortgage loans, affects the ability of companies to issue paper. As a result, the interest rates charged by investors increase. In short, innovations in securitization spread widely the risks related to the inability or unwillingness of homeowners to make their mortgage payments.

Stating the problem: trenching and the correlation coefficient

The focus of this paper is the importance of default correlation estimations in measuring credit risk in subprime portfolios. Default correlation, defined by Nagpal and Bahar (2001) as the relationship between default probabilities and joint default probabilities, is a measure of the dependence among risks. Therefore, it is a key variable in the evaluation of the credit loss distribution, and a necessary input in the assessment of the value of the portfolio at risk due to credit. The risk of the portfolio, and the capital needed to manage that risk, will be underestimated if the effect of shocks to the portfolio through correlation are ignored (Gordy, 2000) (Carey, 2000).

In general, the notion of default correlation considers that common underlying factors, such as macroeconomic or geographically specific events, cause the default events to cluster (Calem and LaCour-Little, 2001). Based on observations of historical rates of default, Nagpal and Bahar (2001) report that credit events are correlated. In the case of subprime lending, Davis and Pennington (2007) find that increases in home values and local market conditions are significant predictors of default.

In reference to commercial portfolios, numerous studies show that as the credit quality of the portfolio declines, default correlation becomes more relevant. Among others, Zhou (1997) finds that implied default correlations which are close to zero in the case of highly rated firms, become much larger for firms with lower ratings. Along the same lines, Lucas et al. (2001) results show that for a given correlation, a better quality portfolio reduces extreme credit loss quantiles. Lastly, Loffler (2003) reports that, for uncertainty in the 1% value-at-risk, correlation uncertainty for lower quality portfolios is more significant than for better rated portfolios.

With regards to subprime lending, Cowan and Cowan (2004) also find that default correlation increases as the internal ratings of the lender decline. In addition, they conclude the subprime sector shows larger default correlations than commercial bonds and loans portfolios.

Furthermore, during a recent conference, Jorion (2007) defended that deal breaks are dependent, particularly in falling markets, supporting the idea that portfolio risk depends heavily in correlations. In summary, the common findings of these authors reinforce the idea that underestimating default correlations results in greater model risk.

Several methodologies have been used to estimate default correlations within portfolios. For example, using Merton's (1974) assumption that default can take place at a single moment in time, one can employ the firms' liability structures, asset values, and variance/covariance matrices, to find an analytical solution for correlation. First-passage-time models of default risk eliminate this assumption. Using this approach, Loffler (2003) estimated default correlations based on the joint distribution of asset values, while Crouhy et al. (2000) utilized equity prices. Default risk has also been estimated using Monte Carlo simulation. Lastly, some authors such as Cowan and Cowan (2004) use historical default volatilities to determine default correlations. In this case, their estimations depend on two assumptions: that all loans within a risk class have identical default rates, and that internal credit ratings are consistent.

Until recently though, correlation between different chunks of debt was thought to be small. The reason was that the underlying risks were assumed to be idiosyncratic, and the likelihood of numerous companies defaulting at the same time was believed to be insignificant. However, during this past crisis the observed large price swings, and the significant downgrades in AAA structures of the mortgages and their effect in the quality of the debt, have been interpreted as investors becoming more fearful of systemic risk due to price correlation within the CDO market, the potential rise in default correlation, and asset correlation (Fender and Hördahl, 2007). In the case of our current crisis, the underlying factors might have been the downturn in the value of the real estate properties used as loan collateral, and the increasing interest rates.

How does subprime lending and mortgages play into the current crises? What factors differentiate this crisis from those of 1987 and 1998? Given that the downturn in the real estate market and the raising interest rates have been proposed to explain the crises, in reading the description of events at the beginning of the paper, one has to consider the interaction between the real estate market and the subprime industry, and how news feedback into the market. Could there be a relationship between these events and the observation that the correlation coefficient among trades of pools of credit derivatives has been moving in unusual ways[xiv]?

The correlation coefficient shows the strength and direction of a linear relationship between variables. If the variables are independent, the correlation is 0. The opposite is not true, since the correlation coefficient only recognizes linear dependencies between two variables. The correlation is 1 in the case of an increasing linear relationship, −1 in the case of a decreasing linear relationship, and some value in between in all other cases. The interpretation of this coefficient depends on the context, but the closer it is to either −1 or 1, the stronger the correlation between the variables.

We define the correlation coefficient $\rho_{x,y}$ between two random variables X and Y with expected (mean) values μ_x and μ_y, and standard deviations σ_x and σ_y as:

$$\rho_{x,y} = \frac{\mathrm{cov}(X,Y)}{\sigma_X \sigma_Y} = \frac{E((X-\mu x)(Y-\mu y))}{\sigma_X \sigma_Y}$$

Where E is the expected value operator and cov means covariance.

The Pearson coefficient defined below is the best estimate of the correlation of X and Y if X and Y are both normally distributed when using data from a sample:

$$r_{xy} = \frac{\sum (x_i - \overline{x})(y_i - \overline{y})}{(n-1)s_x s_y}$$

Where we have a series of n measurements of X and Y written as x_i and y_i with i = 1, 2, ..., n, $\overline{x}$ and $\overline{y}$ are the sample means of X and Y, s_x and s_y are the sample standard deviations of X and Y, and the sum is from i = 1 to n.

How likely is senior to experience a loss? What from a risk management point of view might inform us of the reasons for the significant downgrades in AAA structures of mortgages? In our discussion about securitization, we mentioned that by pooling many mortgages with similar default probabilities a bond with lower probability of total default could be created. However, one has to consider that the mortgage loan portfolio's volatility is a function of the correlation coefficient of the assets that make up the portfolio.

We define the standard deviation of a portfolio (σ_p) as:

$$\sigma_p = \sqrt{\sigma_p^2}$$

where the variance is $\sigma_p^2 = \sqrt{_i \sqrt{_j w_i w_j \sigma_i \sigma_j \rho_{ij}}}$

and

w = the weights of the total wealth invested in each asset

ρ = the correlation coefficient between the assets

For example, a three asset portfolio, the variance is:

$$\sigma^2_p = w^2_A\sigma^2_A + w^2_B\sigma^2_B + w^2_C\sigma^2_C + 2\, w_A w_B\, \rho_{AB}\, \sigma_A\sigma_B + 2\, w_A w_C\, \rho_{AC}\, \sigma_A\sigma_C + 2\, w_B w_C\, \rho_{BC}\, \sigma_B\sigma_C$$

The number of covariance terms ($\rho_{AC}\, \sigma_A\sigma_C$) that need to be computed as the number of assets in the portfolio increases is equal to: $\frac{n(n-1)}{2}$

Let us say we have a portfolio of two mortgages, A and B. Both have a standard deviation (σ) of 10, and 50% of our funds are invested in each mortgage (w = 0.50). If the correlation coefficient (ρ) is 1, then the standard deviation of the portfolio (σ_p) is:

$$\sigma_p = \sqrt{w_A^2\sigma_A^2 + w_B^2\sigma_B^2 + 2w_A w_B \rho_{AB}\sigma_A\sigma_B} =$$

$$\sqrt{0.5^2 100 + 0.5^2 100 + 2*0.5*0.5*1*10*10} = 10$$

On the other hand, if the correlation coefficient (ρ) is 0, then the standard deviation of the portfolio (σ_p) is:

$$\sigma_p = \sqrt{w_A^2\sigma_A^2 + w_B^2\sigma_B^2 + 2w_A w_B \rho_{AB}\sigma_A\sigma_B} =$$

$$\sqrt{0.5^2 100 + 0.5^2 100 + 2*0.5*0.5*0*10*10} = 7.07$$

Let us say we have a portfolio with one hundred mortgages. Every individual mortgage has a standard deviation (σ) of 10, and an equal proportion of our funds are invested in each of them. If the correlation coefficient (ρ) among those mortgages is 1, then the standard deviation of the portfolio (σ_p) is: $\sigma_{portfolio} = \frac{\sigma}{10}$

$$\sigma_p = \sqrt{(1/100)^2 100*100 + 2*\frac{1}{100}*\frac{1}{100}*1*10*10*4950} = 10$$

Where 4950 is the covariance term calculated as: $\frac{n(n-1)}{2}$, and n is the number of assets in the portfolio.

Other things equal, but with a correlation coefficient (ρ) among those mortgages of zero, the standard deviation of the portfolio (σ_p) is reduced to:

$$\sigma_p = \sqrt{(\frac{1}{100})^2 *100*100 + 2*\frac{1}{100}*\frac{1}{100}*0*10*10*4950} = 1$$

Therefore, if each mortgage within the portfolio has the same standard deviation (σ), and there is perfect correlation among the underlying assets, the standard deviation of the portfolio is equal to the standard deviation of each of the mortgages. No diversification of risk has been achieved: the standard deviation is the same as if there was just one asset in the portfolio, and default on one mortgage is the same as default on all.

On the other hand, if the underlying assets are completely uncorrelated, then the standard deviation of the portfolio would equal $(\frac{\sigma}{\sqrt{n}})$. That is, if we were to have one hundred mortgages that happened to hold a correlation coefficient of zero, the standard deviation of the portfolio $\sigma_{portfolio} = \frac{\sigma}{10}$. In this case, the standard deviation is 10 times smaller than if correlated $(\frac{\sigma}{\sqrt{n}})$. Therefore, if the assets are uncorrelated, there is virtually no chance of default (see Table A in the Appendix for complete results). In summary, the critical factor is not the number of assets within the portfolio per se, but the correlation coefficient among the assets. Thus, correlation is the key element in estimating the likelihood of loss in senior trade.

At this point, at least two questions come to mind: why is the correlation a key factor, particularly in subprime MBSs? What could explain the underestimation of the standard deviations of these portfolios?

Let us recall that the structured financial transactions related to the subprime mortgage industry we have been revising, can be viewed as a number of small loans of a similar type packaged together into a series of "buckets", which are then sliced into "tranches". During our description of the crisis, one recurrent event that fed back into the problem was the market volatility as suggested by large price swings with spreads. Since the interest rate of each tranche is a function of the credit rating originally assigned by the credit rating company (CRA), CRAs have been blamed for contributing to the depth of the crises due to errors of judgement and/or slow response to changing conditions. Such criticisms intensified in the wake of large losses in the CDO market despite the products' top ratings. Particularly, in the cases of AAA products, which in many instances were subsequently downgraded or defaulted[xv]. Given these considerations, at least three reasons can be proposed to explain these facts.

First of all, standard deviations and correlation coefficients are estimated with historical data. If the recent prior experience is of a rising housing market, the use of a historical data from previous periods to calculate standard deviations may result in a number that is inadequate in a cycle of decreasing housing values. The reason is that in a booming housing market, equity is created by the homeowners and the willingness or need to default under those circumstances is ameliorated. On the other hand, in a decreasing value cycle, equity is being destroyed and a larger number of homeowners could be perceived as being more willing to default. This is consistent with Danis and Pennington-Cross (2007) observations, and Jorion's (2007) comments.

A second motive correlation coefficients among subprime mortgages could be underestimated is that, unlike with traditional prime rated mortgages which use income and assets as collateral, subprime mortgages are only asset price based. That is, the loans are granted on the base of the value of the underlying collateral, namely the property being mortgaged. The fact that asset values are more correlated than income could explain the findings that the correlation coefficients in the subprime loan sector behave in a different way than those in the prime lending industry.

Lastly, the third reason proposed in this paper, is that the teaser rates on ARMs structures reset all at same time. This would result in jumps on loan payments that, on an increasing interest rate environment like the one recently experienced, could go from for example, \$700 to \$2,500 monthly. The pressure of the significantly larger liquidity needs on the part of the loan holders to cover the payments could result on higher default correlation since everyone within this loan class is exposed to the increase at the same time.

Conclusion

This paper focuses on the relevance of default correlations as a key variable in the current financial crisis. We propose that the correct estimation of the correlation coefficient among the values of the underlying collateral of the MBSs is critical in assessing default risks. We show empirically how different estimates of such correlation coefficient impact the sigmas of the portfolio of assets significantly. We propose three reasons to explain the underestimation of these coefficients in the past: the use of recent historical data in bull housing markets, the fact that subprime mortgages are only asset price based, and lastly the event of teaser rates resetting at the same time. This paper supports the idea that improved understanding of the correlations implied within subprime loan portfolios would help rating companies, lenders, and regulators improve their evaluation of default risks.

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APPENDIX - TABLE A

This table shows the standard deviations of different portfolios with assets from 1 to 100, and correlation coefficients 0, 1, and 0.5. Where, the standard deviation of a portfolio is:

$\sigma_p = \sqrt{\sigma_p^2}$ where the variance is $\sigma_p^2 = \sqrt{{}_i\sqrt{{}_j w_i w_j \sigma_i \sigma_j \rho_{ij}}}$ With σ_i - standard deviation for Asset i, w_i - wealth for asset i. In the columns: NA- Number of Assets, CT- Covariance Terms, w^2 - % Wealth, w - wealth squared, ρ_1 - Correlation Coefficient 1, ρ_0 - Correlation Coefficient 0, $\rho_{0.5}$ - Correlation Coefficient 0.5

NA	CT	w^2	w	σ	σ^2	ρ_1	ρ_0	$\rho_{0.5}$	σ_p^2 ρ_1	σ_p ρ_1	σ_p^2 ρ_0	σ_p ρ_0	σ_p^2 $\rho_{0.5}$	σ_p $\rho_{0.5}$
1	0	1,00	1,00	10,00	100,00	1	0	0,5	100,00	10,00	100,00	10,00	100,00	10,00
2	1	0,50	0,25	10,00	100,00	1	0	0,5	100,00	10,00	50,00	7,07	75,00	8,66
3	3	0,33	0,11	10,00	100,00	1	0	0,5	100,00	10,00	33,33	5,77	66,67	8,16
4	6	0,25	0,06	10,00	100,00	1	0	0,5	100,00	10,00	25,00	5,00	62,50	7,91
5	10	0,20	0,04	10,00	100,00	1	0	0,5	100,00	10,00	20,00	4,47	60,00	7,75
6	15	0,17	0,03	10,00	100,00	1	0	0,5	100,00	10,00	16,67	4,08	58,33	7,64
7	21	0,14	0,02	10,00	100,00	1	0	0,5	100,00	10,00	14,29	3,78	57,14	7,56
8	28	0,13	0,02	10,00	100,00	1	0	0,5	100,00	10,00	12,50	3,54	56,25	7,50
9	36	0,11	0,01	10,00	100,00	1	0	0,5	100,00	10,00	11,11	3,33	55,56	7,45
10	45	0,10	0,01	10,00	100,00	1	0	0,5	100,00	10,00	10,00	3,16	55,00	7,42
11	55	0,09	0,01	10,00	100,00	1	0	0,5	100,00	10,00	9,09	3,02	54,55	7,39
12	66	0,08	0,01	10,00	100,00	1	0	0,5	100,00	10,00	8,33	2,89	54,17	7,36
13	78	0,08	0,01	10,00	100,00	1	0	0,5	100,00	10,00	7,69	2,77	53,85	7,34
14	91	0,07	0,01	10,00	100,00	1	0	0,5	100,00	10,00	7,14	2,67	53,57	7,32
15	105	0,07	0,00	10,00	100,00	1	0	0,5	100,00	10,00	6,67	2,58	53,33	7,30
16	120	0,06	0,00	10,00	100,00	1	0	0,5	100,00	10,00	6,25	2,50	53,13	7,29
17	136	0,06	0,00	10,00	100,00	1	0	0,5	100,00	10,00	5,88	2,43	52,94	7,28
18	153	0,06	0,00	10,00	100,00	1	0	0,5	100,00	10,00	5,56	2,36	52,78	7,26
26	325	0,04	0,00	10,00	100,00	1	0	0,5	100,00	10,00	3,85	1,96	51,92	7,21
27	351	0,04	0,00	10,00	100,00	1	0	0,5	100,00	10,00	3,70	1,92	51,85	7,20
28	378	0,04	0,00	10,00	100,00	1	0	0,5	100,00	10,00	3,57	1,89	51,79	7,20
29	406	0,03	0,00	10,00	100,00	1	0	0,5	100,00	10,00	3,45	1,86	51,72	7,19
30	435	0,03	0,00	10,00	100,00	1	0	0,5	100,00	10,00	3,33	1,83	51,67	7,19
31	465	0,03	0,00	10,00	100,00	1	0	0,5	100,00	10,00	3,23	1,80	51,61	7,18
32	496	0,03	0,00	10,00	100,00	1	0	0,5	100,00	10,00	3,13	1,77	51,56	7,18
33	528	0,03	0,00	10,00	100,00	1	0	0,5	100,00	10,00	3,03	1,74	51,52	7,18
34	561	0,03	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,94	1,71	51,47	7,17
35	595	0,03	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,86	1,69	51,43	7,17
36	630	0,03	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,78	1,67	51,39	7,17
37	666	0,03	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,70	1,64	51,35	7,17
38	703	0,03	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,63	1,62	51,32	7,16
39	741	0,03	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,56	1,60	51,28	7,16
40	780	0,03	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,50	1,58	51,25	7,16
41	820	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,44	1,56	51,22	7,16
42	861	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,38	1,54	51,19	7,15
43	903	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,33	1,52	51,16	7,15

19	171	0,05	0,00	10,00	100,00	1	0	0,5	100,00	10,00	5,26	2,29	52,63	7,25	**44**	946	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,27	1,51	51,14	7,15
20	190	0,05	0,00	10,00	100,00	1	0	0,5	100,00	10,00	5,00	2,24	52,50	7,25	**45**	990	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,22	1,49	51,11	7,15
21	210	0,05	0,00	10,00	100,00	1	0	0,5	100,00	10,00	4,76	2,18	52,38	7,24	**46**	1035	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,17	1,47	51,09	7,15
22	231	0,05	0,00	10,00	100,00	1	0	0,5	100,00	10,00	4,55	2,13	52,27	7,23	**47**	1081	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,13	1,46	51,06	7,15
23	253	0,04	0,00	10,00	100,00	1	0	0,5	100,00	10,00	4,35	2,09	52,17	7,22	**48**	1128	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,08	1,44	51,04	7,14
24	276	0,04	0,00	10,00	100,00	1	0	0,5	100,00	10,00	4,17	2,04	52,08	7,22	**49**	1176	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,04	1,43	51,02	7,14
25	300	0,04	0,00	10,00	100,00	1	0	0,5	100,00	10,00	4,00	2,00	52,00	7,21	**50**	1225	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	2,00	1,41	51,00	7,14

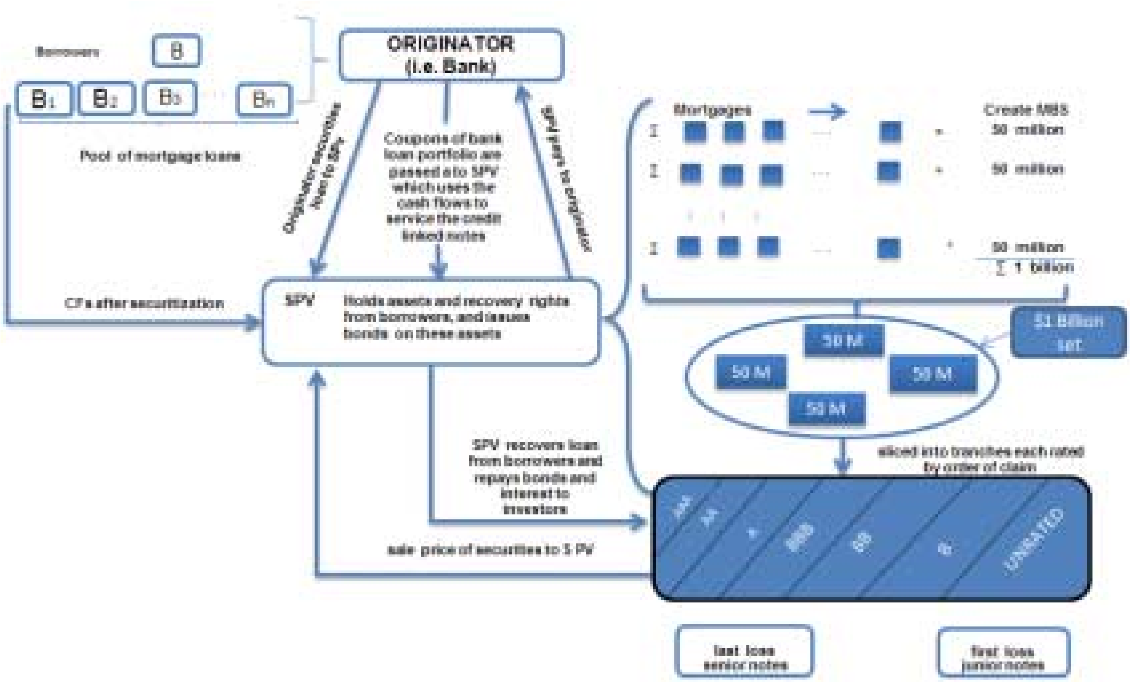
Table A (cont.)

NA	CT	w^2	w	σ	σ^2	ρ_1	ρ_0	$\rho_{0.5}$	σ_p^2 ρ_1	σ_p ρ_1	σ_p^2 ρ_0	σ_p ρ_0	σ_p^2 $\rho_{0.5}$	σ_p $\rho_{0.5}$	**NA**	CT	w^2	w	σ	σ^2	ρ_1	ρ_0	$\rho_{0.5}$	σ_p^2 ρ_1	σ_p ρ_1	σ_p^2 ρ_0	σ_p ρ_0	σ_p^2 $\rho_{0.5}$	σ_p $\rho_{0.5}$
51	1275	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,96	1,40	50,98	7,14	**76**	2850	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,32	1,15	50,66	7,12
52	1326	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,92	1,39	50,96	7,14	**77**	2926	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,30	1,14	50,65	7,12
53	1378	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,89	1,37	50,94	7,14	**78**	3003	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,28	1,13	50,64	7,12
54	1431	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,85	1,36	50,93	7,14	**79**	3081	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,27	1,13	50,63	7,12
55	1485	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,82	1,35	50,91	7,14	**80**	3160	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,25	1,12	50,63	7,12
56	1540	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,79	1,34	50,89	7,13	**81**	3240	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,23	1,11	50,62	7,11
57	1596	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,75	1,32	50,88	7,13	**82**	3321	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,22	1,10	50,61	7,11
58	1653	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,72	1,31	50,86	7,13	**83**	3403	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,20	1,10	50,60	7,11
59	1711	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,69	1,30	50,85	7,13	**84**	3486	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,19	1,09	50,60	7,11
60	1770	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,67	1,29	50,83	7,13	**85**	3570	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,18	1,08	50,59	7,11
61	1830	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,64	1,28	50,82	7,13	**86**	3655	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,16	1,08	50,58	7,11
62	1891	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,61	1,27	50,81	7,13	**87**	3741	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,15	1,07	50,57	7,11
63	1953	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,59	1,26	50,79	7,13	**88**	3828	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,14	1,07	50,57	7,11
64	2016	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,56	1,25	50,78	7,13	**89**	3916	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,12	1,06	50,56	7,11
65	2080	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,54	1,24	50,77	7,13	**90**	4005	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,11	1,05	50,56	7,11

66	2145	0,02	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,52	1,23	50,76	7,12
67	2211	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,49	1,22	50,75	7,12
68	2278	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,47	1,21	50,74	7,12
69	2346	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,45	1,20	50,72	7,12
70	2415	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,43	1,20	50,71	7,12
71	2485	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,41	1,19	50,70	7,12
72	2556	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,39	1,18	50,69	7,12
73	2628	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,37	1,17	50,68	7,12
74	2701	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,35	1,16	50,68	7,12
75	2775	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,33	1,15	50,67	7,12
91	4095	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,10	1,05	50,55	7,11
92	4186	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,09	1,04	50,54	7,11
93	4278	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,08	1,04	50,54	7,11
94	4371	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,06	1,03	50,53	7,11
95	4465	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,05	1,03	50,53	7,11
96	4560	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,04	1,02	50,52	7,11
97	4656	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,03	1,02	50,52	7,11
98	4753	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,02	1,01	50,51	7,11
99	4851	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,01	1,01	50,51	7,11
100	4950	0,01	0,00	10,00	100,00	1	0	0,5	100,00	10,00	1,00	1,00	50,50	7,11

TABLE 1 The first and second columns show the tranches and ratings assigned to each. The last column describes the risks assumed by each tranche of investors.		
Rating	**Tranche**	**Description**
BBB-	E (equity)	absorbs the first 10% of losses on the portfolio
BBB	D (mezzanine)	absorbs the next 10% of losses
A	C (mezzanine)	absorbs the following 10% of losses
AA	B (mezzanine)	the next 10%
AAA	A (senior)	would absorb the final losses

Graph 1



Footnotes

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[i] The crisis is ongoing and so far more than 100 subprime mortgage lenders failed or file for bankruptcy, most prominently New Century Financial Corporation, previously the nation's second biggest subprime lender. The failure of these companies has caused prices in the $6.5 trillion mortgage backed securities market to collapse, threatening broader impacts on the U.S. housing market and economy as a whole. For a summary of events see http://en.wikipedia.org/wiki/2007_subprime_mortgage_financial_crisis.
[ii] Expansión, November 7th 2007, page 29.
[iii] http://biz.yahoo.com/ap/071101/foreclosure_rates.html .
[iv] The Federal Reserve Board's Regulation B (implementing the Equal Credit Opportunity Act), prohibits credit-scoring considering "prohibited bases" such as race, skin color, religion, national origin, sex, and marital status.
http://www.federalreserve.gov/boarddocs/press/bcreg/2003/20030305/attachment.pdf
[v]http://money.cnn.com/galleries/2007/real_estate/0704/gallery.paly_the_subprime_blame_game/index.html?section=money_realestate
[vi] Material Loss Review of Next Bank, NA (OIG-03-024) November 26, 2002, page 48, can be retrieved from http://www.treasury.gov/inspector-general/audit-reports/2003/oig03024.pdf
[vii] Sources: Material Loss Review of Next Bank, NA (OIG-03-024) November 26, 2002, p. 14 which can be retrieved from http://www.treasury.gov/inspector-general/audit-reports/2003/oig03024.pdf; http://www.myfico.com; and http://www.usatoday.com/money/perfi/columnist/waggon/2007-03-15-subprime-woes_N.htm.
[viii] The FICO score distribution ranges between 300 and 850, it is skewed to the left with 60% of scores between 650 and 799, has a median of 723, and an average of 678. FICO has disclosed some of the variables considered when calculating an individual's score: punctuality of payment in the past, the amount of debt expressed as the ratio of current revolving debt to total available revolving credit, length of credit history, types of credit used, and recent search for credit and/or amount of credit obtained recently (http://www.myfico.com).
[ix] A debt-to-income ratio (DTI) is the percentage of a consumer's monthly gross income that goes toward paying debts. There are two main kinds of DTI: the front ratio, which indicates the percentage of income that goes toward total housing costs, and the back ratio, which shows the percentage of income that goes toward paying all recurring debt payments.
[x] By 2005, about twenty percent of all mortgage originations in the U.S. were subprime, totalling $600 billion. (Report and Recommendations by the Majority Staff of the Joint Economic Committee October 2007, p.10, which can be retrieved from http://jec.senate.gov/Documents/Reports/10.25.07OctoberSubprimeReport.pdf). The approximate amount of subprime mortgages outstanding as of March 2007 is $1,3 trillion (http://www.msnbc.msn.com/id/17584725).
[xi] Interest-only mortgages, allow borrowers to pay only interest for a period of time; in "pick a payment" loans, borrowers choose their monthly payment (full payment, interest only, or a minimum payment which may be lower than the payment required to reduce the balance of the loan); and with adjustable rate mortgages (ARM), they set an initial fixed rate that converts to variable within a period of time.
[xii] In the Global Financial System's January 2005 report, page 1, "The role of ratings in structured finance: issues and implications", the following definition of structured finance is provided. "Structured finance instruments can be defined through three key

characteristics: (1) pooling of assets (either cash-based or synthetically created); (2) tranching of liabilities that are backed by the asset pool; (3) de-linking of the credit risk of the collateral asset pool from the credit risk of the originator, usually through use of a finite-lived, standalone special purpose vehicle (SPV)."(Can be access from: http://www.bis.org/publ/cgfs23.pdf?noframes= 1).

[xiii] The Committee on the Global Financial System explained tranching in the following manner: "A key goal of the tranching process is to create at least one class of securities whose rating is higher than the average rating of the underlying collateral pool or to create rated securities from a pool of unrated assets. This is accomplished through the use of credit support (enhancement), such as prioritization of payments to the different tranches." (Global Financial System's January 2005 report, page 1, can be access from: http://www.bis.org/publ/cgfs23.pdf?noframes=1).

[xiv] See Financial Times, November 6th 2007, page 41

[xv] For instance, losses on $340.7 million worth of collateralized debt obligations (CDO) issued by Credit Suisse Group added up to about $125 million, despite being rated AAA or Aaa by Standard & Poor's, Moody's Investors Service and Fitch Group.(Can be retrieved from http://www.iht.com/articles/2007/05/31/bloomberg/bxinvest.php)

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